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MEASUREMENT PROCEDURES IN PROGRAMED INSTRUCTION.
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FIVE EXPERIMENTS WERE CONDUCTED TO DETERMINE METHODS OF USING CONVENTIONAL MEASUREMENT PROCEDURES WITH PROGRAMED INSTRUCTION. THE EXPERIMENTS FOCUSED ON THREE SUBJECT AREAS - CAPITALIZATION, PUNCTUATION, AND ARITHMETIC MANIPULATION OF COMMON FRACTIONS. PUPILS FROM THE FOURTH TO SIXTH GRADES OF THREE ELEMENTARY SCHOOL DISTRICTS COMPRISED THE SAMPLE. THE SAME GENERAL STRATEGY WAS EMPLOYED IN EACH SUBJECT AREA. BEHAVIORAL OBJECTIVES WERE SPECIFIED AND THEN THE INSTRUCTIONAL SEQUENCES WERE PREPARED TO BE CONSISTENT WITH THE SPECIFICATION. THE PROGRAMS AND THEIR MEASUREMENT DEVICES WERE INCLUDED IN THE PRELIMINARY EXPERIMENTS. THE FINDINGS PROVIDED A BASIS FOR PRECISE ANALYSIS, REFINED SEQUENCE, AND A SET OF MEASURES. A FINAL STUDY WAS CONDUCTED. THE RESULTS OF THE EXPERIMENTS INDICATED THAT FORMAL MEASUREMENT CAN FULFILL AN IMPORTANT ROLE IN PROGRAMED INSTRUCTION, BUT THAT CONTROL IS REQUIRED ON NON PSYCHOMETRIC AS WELL AS PSYCHOMETRIC VARIABLES. FURTHER RESEARCH ACTIVITY WAS SUGGESTED TO DIRECT IMMEDIATE ATTENTION TOWARD MAXIMIZING THE EXTERNAL VALIDITY OF THE RESULTS, AND THE DEVELOPMENT OF A SEQUENCE OF INSTRUCTIONAL CUES AND TEST ITEMS FOR A COMPUTER TYPE SYSTEM. (RS)

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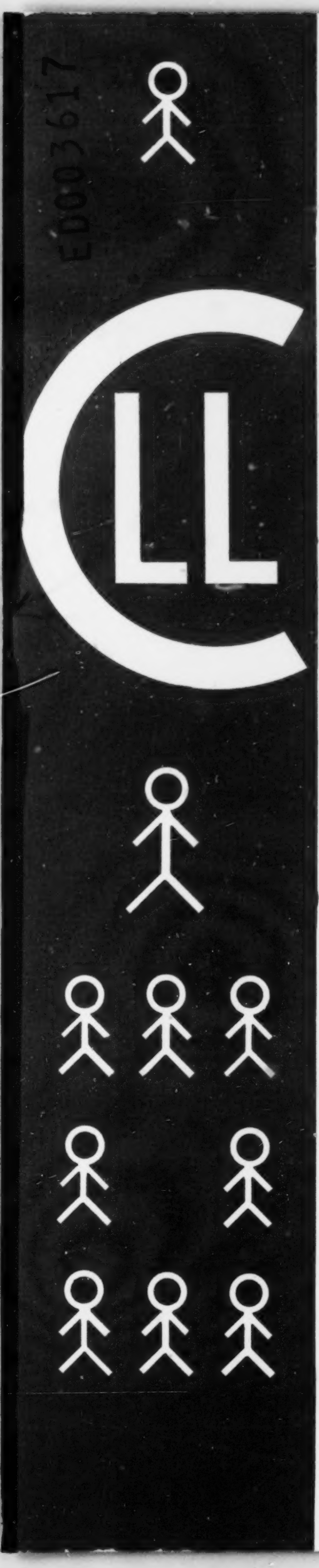

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Vernon S. Gerlach

Final Report
Title VII Project 909
National Defense Education Act of 1958
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CLASSROOM LEARNING LABORATORY

experimental analyses of student behavior

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CHAPTER I
INTRODUCTION

Programmed instruction is at least partially rooted in the technology of educational and psychological measurement. The early devices developed by S. L. Pressey (1950) were designed as concomitant automatic test scoring and self instructional machines. However, the "teaching machine movement" of the last decade has been influenced very little by psychometric technology. Developments in self instructional programing have grown out of experimentation in learning rather than measurement. The potential power of a properly sequenced set of stimuli in shaping behavior has captured the imagination of self instructional enthusiasts and experimenters alike. The potential contribution of the well-developed technology of educational and psychological measurement in promoting the efficiency of programmed instruction has been largely overlooked.

Some programmed instruction specialists have implied that self instruction subsumes formal measurement. Skinner (1958) suggests that a random or pre-designated sample of the students' responses to the program itself may be recorded and considered a test. In general, self instructional programmers have regarded formal measurement as part and parcel of traditional education which "the new technology" has rendered obsolete. This negative predisposition has led to a rather cavalier disregard of formal measurement.

Measurement specialists, for their part, have not been overly aggressive in demonstrating the relevance of their technology for programmed instruction. Heath (1962) has briefly surveyed the potential role of tests in programmed instruction, categorizing the functions under four headings:

1. evaluation of student achievement
2. evaluation of the program
3. use in program development
4. diagnosis and guidance

These categories represent conventional psychometric rubrics for measurement "application." As might be expected, Heath's discussion of achievement testing is the most specific, since this comes close to the core of educational measurement technology. The discussion points out the inadequacy of a single criterion frame as a reliable measure of student achievement. It also recognizes that the test must sample a specified population of behavior. Leaving achievement testing, the discussion becomes increasingly general in nature and takes on a conditional "may" and "might" mood in keeping with the tentative exploratory nature of the suggestions offered. The final summary reflects very well the spirit of the paper: "In summary, we find that programmed learning presents a challenge and an opportunity for the test constructor, just as testing presents a challenge and an aid to the programmer."

Paul Jacobs, a member of the Educational Testing Service group along with Heath, has issued a report (1962) which is longer, more elaborate and formal than Heath's but is definitely in the same vein. Jacobs describes the steps involved in test construction (at its idealized best) and points out parallels between the task of the test constructor and the programmer. Again the discussion is at a very general global level and is necessarily intraverbal and conditional since no empirical basis has as yet been built to support the analogies presented.

Heath and Jacobs have performed a useful service in collating and summarizing psychometric data and lore which might have some relevance for programmed instruction. Such information should be a part of the "general education" knowledge which all educational researchers possess as an intraverbal repertoire. The difficulty is that the relevance of the information for an instructional technology is at best indirect. In the absence of direct empirical support, an intraverbal repertoire functions only within certain verbal confines; it generates no direct cues for persons faced with actually applying an application rather than talking about applying it. One can glibly state, "tests should be useful in evaluating programs," but the statement leaves the question of how one puts them to use unanswered.

The few researchers who have seriously attempted to incorporate defensible psychometric procedures into programmed instruction sequences have found that the transition between psychometry and programing is not the easy and natural transfer of training that onlookers imply. Glaser (1963), for example, in describing the measurement concerns growing out of his research concludes that "many of us are beginning to recognize the problems of assessing existing levels of competence and achievement and the conditions that produce them require some additional consideration" (p. 521).

Glaser's discussion clarifies several difficulties in applying measurement in programmed instruction by making more precise discriminations of procedures which have previously been considered only in a global generalized fashion. For example, Glaser makes an important distinction between *norm referenced* measures and *criterion referenced* measures in the evaluation of achievement. He points out that the results of an achievement test can be used to rank the examinee either along a relative continuum of capability with respect to a specified group of persons or along an absolute continuum of proficiency with respect to a specified behavioral criterion.

> In large part, achievement measures currently employed in education are norm referenced. This emphasis upon norm referenced measures has been brought about by the preoccupation of test theory with aptitude, and with selection and prediction problems; normed referenced measures are useful for this kind of work in correlational analysis (p. 520).

Although norm reference measures are indisputedly useful in the correlational context (Cronbach, 1957) where the emphasis is on the prediction of behavior using R-R relationships, they are of little value in a programmed instructional context where the emphasis is on the control of behavior using S-R relationships. Where the concern is with whether or not an individual is sufficiently competent to go on to the next step in the instructional program, a normative score is of little help. What is required as Glaser points out is

> ...explicit information as to what the individual can or cannot do. Criterion referenced measures indicate the content of the behavioral repertory, and the correspondence between what an individual does and the underlying continuum of achievement. Measures which assess student achievement

> in terms of a criterion standard thus provide information as to the degree of competence attained by a particular student which is independent of reference to the performance of others (p. 520).

Glaser makes a second important distinction between tests designed to provide information about individual differences in contrast to those designed to identify individual similarities. Tests designed to measure individual differences are constructed to "maximize the variability of the distribution of scores that are obtained." Traditional item analysis procedures are designed to do this very thing. The requirements of programmed instruction, on the other hand, appear to demand a type of test "contructed so as to maximize the discriminations made between groups treated differently and to minimize the differences between the individuals in any one group. Such a test will be sensitive to the difference produced by instructional conditions" (p. 520).

Silberman (1964), in a paper analogous to Glaser's in that it grew out of empirical research data, describes the inadequacy of standard item analysis procedures for tests in programmed instruction:

> Since the purpose of a program evaluation test is to measure the behavior that should have been produced in all of the students receiving the program, the items may be very easy. Such items do not discriminate among students and therefore result in low item discrimination indices. Hence, traditional item analysis data may not be particularly useful for program evaluation tests. Effective programs, yielding a very limited spread of scores on a posttest, attenuate any coefficients which are a function of variance among the test scores. Test-retest correlations, item-test correlations, and test-criterion correlations will all be reduced by a restricted range of posttest scores. The validity of a test, therefore, must be judged in terms of relevance of content and objectives, as well as statistical indices. If test items sample the essential subject matter that the student has learned from the program, and if items are not eliminated on the basis of item-test discrimination, correlations between success or failure on each item and the criterion score are zero if everyone answers each item correctly. Such a test may not discriminate well among students who have received the program but may still discriminate between students who have received the program and those who have not (p. 6-7).

Glaser and Silberman join in emphasizing the critical need for refined procedures for specifying criterion behavior. "The specification of the characteristics of maximum or optimum achievement after a student has been exposed to the course of instruction poses more difficult problems of criterion delineation" (Glaser, p. 520). "In summary, it is proposed that a high payoff would be obtained if as much effort were devoted to the dependent variable as is now spent on the independent variable in programing research. The nature of the criterion variable determines the outcome of the experiment no less than the treatment conditions themselves" (Silberman, p.8).

The problem of specifying instructional objectives is not a novel one. More than 30 years ago Ralph Tyler (1934) clearly outlined the criterion for an adequate objective:

> Each objective must be defined in terms which clarify the kind of behavior which the course should help to develop among the students; that is to say, a statement is needed which explains the meaning of the objective by describing the reactions we can expect of persons who have reached the objective. This helps to make clear how one can tell when the objective is being attained since those who are reaching the objective will be characterized by the behavior specified in this analysis (p. 3).

This statement could hardly be improved upon as a specification of terminal behavior for writers of objectives. Why then are statements of objectives which meet the criterion still so rare, even in the programmed instructional context? It would appear that this is another example of misplaced reliance on intraverbal behavior as a basis for instructional technology. That is, treatments of the criterion variable have talked about the problem rather than seeking operational procedures for eliminating it. Although we have valuable taxonomies of objectives (Bloom, 1956) and criteria for criteria (Weitz, 1961) we are totally lacking in procedures for developing objectives. Without procedural cues to guide their behaviors, people who should be writing behavioral objectives simply don't.

An important step in changing this situation is Mager's (1962) brief programmed text which does an adequate job of shaping the reader's discrimination of behaviorally and non-behaviorally stated objectives.

The salience of the criterion problem in programmed instruction has led to its further consideration by researchers in the area of programmed instruction. Although developed independently, the treatments of Gagne (1962) and Hively (1963) share much in common. Each points out that instruction is designed to ensure the acquisition of classes of responses rather than particular responses. What is required then to define the criterion behavior is a specification of the limits of a population of responses which defines the criterion behavior rather than a list of responses which exemplify it. Again, this is not a new concept. It is encompassed by earlier discussions of content validity (Lennon, 1956) and by Bruner's (1960) discussion of the structure of subject matter knowledge. Gagne and Hively, however, go beyond their predecessors by providing specific procedural cues for accomplishing the task and by presenting specific illustrative examples of the products achieved by following the procedures.

Hively uses a standard framework which he calls an item form to define each homogeneous response class. Hively's item forms are typically composed of the following parts:

1. Setup A description of the physical objects the students is dealing with, if any.

2. Instructions The exact words spoken or written to the student in setting his task. (Where two words are bracketed, they may be used interchangeably).

3. Behavior An exact description of what the student is to do.

4. Limits A list of rules defining the allowable variation in each of the above. The word "random," as it appears in many of these rules (e.g., "'random' choice of numbers from 0 through 50"), furnishes the basis for the technical definition of the behavior: the student may be expected to answer all items composed by actually drawing values from a table of random numbers. In practice, however, items would probably be composed by systematically sampling the range of values.

5. Mediating Behavior A description of how the student might go about producing his response to the item, or of how he might be taught to do so.

To illustrate the use of the procedure Hively presents a set of item forms dealing with the concept of a definite set, developed both in terms of physical objects and in terms of symbols. A sample item form is shown on p. 8.

How does one go about preparing an item form. Hively suggests that:

> In general, the task of mapping out a subject matter area in terms of criterion behavior begins with a collection of representative test items. These are classified into item forms, and the item forms are compared, revised, and arranged into sequences. The following questions should be asked about each item:
>
> (a) In what respects could the item be changed and still test the "same thing?" What is the range of possible replacements for specific objects in the "set up" (if there is one) and for specific terms or values in the instructions? What alternative terminology and notation could be used? Does it make any difference whether the instructions are to be presented in spoken or written form? What are alternative forms of acceptable behavior?
>
> (b) What items could precede this one in a program of instruction? How does the student go about providing an answer and what must he know in order to provide it? What items might come next in the program? Could the given item be fitted into alternative programs, building toward different kinds of terminal behavior?

As used by Hively, an item form simply defines a class of behavior; it does not indicate how the behavior is to be established. However, as additional item forms are prepared it is possible to arrange them into tentative sequences which constitute a "behavioral" map of a subject matter that is useful in guiding both instructional and evaluational efforts.

Gagne's treatment dovetails neatly with Hively's by focusing on the arrangement of item forms (which in his terminology would be labeled interchangeably as "learning sets" or "subordinate knowledges") into a hierarchical structure. Gagne states Hively's point (b) above in a slightly different form, and then extends it as follows:

> In considering further the knowledge category, it has been found possible to identify this class of variable more comprehensively in the following way: Beginning with the final task, the question is asked, What kind of capability would an individual have to possess if he were able to

Sample of Hively's Item Form

Setup: A (described earlier as a collection of specified objects on a table with a large shallow red tray and a green tray)

Instructions:

1. The universe is the set of all toy animals in the red tray.
2. Collect the $\left\{\begin{matrix}\text{set}\\\text{subset}\end{matrix}\right\}$ of dogs.

Behavior:

1. S collects the set and encloses it in a circular "frame."
2. If the required set is empty, S says, "The set of dogs is empty."

Limits:

1. "Random" distribution of objects, in the trays and on the table (no ambiguous cases).
2. "Random selection of place names.
3. Successive limits on the classes of object names which may be sampled (class IV is excluded):

	Universe	Subset
a)	class I	class II or III
b)	class I and II	class II and III

   c) Random. This may include contradictions (the universe is the set of dogs in the red tray: collect the set of cats), but it does not include ambiguities (the universe is the set of toy animals in the red tray: collect the set of spheres).

4. Successive limits:
   a) the required set has at least one element.
   b) the required set may be empty.
5. Instructions are spoken.

Mediating Behavior:

Collect all the things in the universe.
Selections: is it a dog?
Yes - put it here: this will be the set of dogs.
No - put it here: this will be the set of all things in the universe which are not dogs.
Select another one ...

> perform this task successfully, were we to give him only instructions? The answer to this question, it turns out, identifies a new class of task which appears to have several important characteristics. Although it is conceived as an internal "disposition," it is directly measurable as a performance. Yet it is not the same performance as the final task from which it was derived. It is in some sense simpler, and it is also more general. In other words, it appears that what we have defined by this procedure is an entity of "subordinate knowledge" which is essential to the performance of the more specific final task.
>
> When this procedural cycle is repeated one identifies a hierarchy of subordinate knowledges, growing increasingly 'simple' and at the same time increasingly general as the defining process continue(s) (p. 356).

Both Gagne and Hively have been selective in the subject matter they chose to "map." It is interesting that each dealt with some aspect of mathematics, a subject which is optimally suited for such procedures. Extension of the procedures on a larger scale and into other areas may get us back into territory describable only as "challenging." However, the level of analysis and the general strategies exemplified by Hively and Gagne appear to have great potential for programmers and examiners alike.

Certainly the application of these strategies should lead to the development of programmed instruction of far greater effectiveness than materials currently available. It should also provide a basis for research in programmed instruction with far greater external validity (Campbell and Stanley, 1963) than studies to date. Consider the concept of bypassing, for example, as an "adaptive programing technique for meeting individual differences." Bypassing does offer an intuitively appealing procedure. Informal observation of group instruction provides ample evidence that individuals differ in terms of component skills. It therefore seems only sensible that a programmed instructional sequence could advantageously capitalize on these individual differences by allowing pupils to skip instruction on components that they have already acquired before coming to the program.

Despite the intuitive appeal of bypassing procedures, empirical investigations of their effectiveness have been characterized chiefly by negative findings. Campbell (1962, 1964) has reviewed eight experiments, each of which failed to achieve the goal of a simple and effective form of bypassing program. Coulson and Silberman (1960) likewise found no significant criterion test difference in comparing a program permitting bypassing with a fixed self instructional sequence, although the bypassing program was completed in significantly less time.

In each of these studies bypassing decisions were based on responses to single criterion frames interspersed within the instructional sequence. As noted above, psychometric experience has long demonstrated that the response to a single test item can hardly be expected to provide a reliable indication of performance. If the diagnostic basis for bypassing is itself inadequate, it is unreasonable to expect bypassing to prove effective. It is likely that the effect of bypassing is a function of the precision of the behavioral analysis of the instructional objective involved and the psychometric adequacy of the measures used to assess the subordinate objectives.

Summary

The preceding review indicates that knowledge of the role of measurement in programmed instruction has progressed from general global recognition of a potential relationship reported in 1962 to specific suggestions for capitalizing on the relationship by 1964. This represents rapid progress. All of the directly relevant literature appeared within the time span covered by the present research project; the preparation of our research proposal in 1961 antedated even Heath's general discussion. Thus, the relationship of the literature to the present study must be viewed as concurrent with the study rather than previous to it. The relevance of each report for our research was carefully assessed at the time of its publication. The articles by Heath (1962), Jacobs (1962), Silberman (1962), and Glaser (1963), each corroborated our findings and helped clarify our thinking about some of the things we had done. Hively's technical report came to our attention in the summer of 1963. As will be evident in later chapters, it contributed greatly to our design of the final experiments. Gagne's 1962 paper was equally influential. But it was not until after we had utilized Hively's item form concept that we were able to make any operational use of Gagne's hierarchial structures. It was also at this time that Gilbert's (1962) mathetics approach acquired operational value for us. Prior to this time we had fully understood Gilbert's system but were unable to use it in our own programing efforts.

The General Research Design

The project involved a series of consecutive experiments to investigate methods of accommodating conventional measurement procedures to the unique requirements of programmed instruction. The general strategy of the research was to incorporate psychometrically adequate tests designed to perform specified functions at various points in the programmed sequence and to note the effect of the measurement procedures on various aspects of pupil performance. Each experiment involved a specified variation in instructional objectives, measurement procedures, or reinforcement contingencies.

Subject Population

Pupils at the fourth to sixth grade levels were used in the experiments. The middle elementary grade level was selected to obtain pupils with basic reading skills to handle simply written texts, but as naive as possible with respect to school experiences.

Each experiment was conducted in regular classrooms under the direct supervision of regular teachers. While the instructional materials were each time pre-tested in the Laboratory with individual pupils prior to the experimentation,we learned early in the project that these results had poor external validity for regular classrooms.

Classes in three neighboring school districts were involved in the experiments. The participating schools are located in suburban areas of a metropolis of approximately 700,000. The schools draw their pupils largely from middle class families. From three to eight classes were involved in each formal experiment.

Instructional Areas

The experiments focused on three subject matter areas: capitalization, punctuation, and arithmetic manipulation of common fractions. These areas were selected to fulfill several requirements.

First, we desired variation both in the nature of the terminal behavior and in the instructional methods conventionally used to achieve this behavior (Gagne, 1964). Capitalization involves a relatively simple response class which must be brought under the control of multiple and complex stimulus classes. Punctuation involves multiple response classes which must again be brought under the control of multiple and complex stimulus classes. Fraction manipulation involves complicated chains of verbal and non-verbal behavior.

Second, we desired topics conventionally included in the elementary curriculum. This criterion was established in an attempt to minimize the artificiality of instruction for both teachers and pupils and thereby maximize the external validity of the results.

Third, we desired topics conventionally pitched at the fourth to sixth grade level but which would still permit freedom to cut across conventional curriculum organization if this should prove desirable.

Finally, we desired topics from which we could derive an identifiable "package" of skills that could be shaped in a program of convenient length. The three instructional areas selected appeared to meet these criteria satisfactorily. The instructional programs used in each experiment were designed to require from 30-40 minutes of class time daily for a period of three to six weeks. Previous experience had demonstrated that very misleading data are collected in a "one day stand" type of experiment if the purpose is to generalize the results to regular classroom instruction. At the same time, programs of a semester's or year's length had proved too cumbersome to manipulate conveniently for the kinds of experiment of interest in this project.

Sequence of Experiments

The research was conducted concurrently in the three subject matter areas. The same general strategy was employed in each area. This involved an initial specification of the behavioral objectives and preparation of an instructional sequence consistent with this specification. The programs and their accompanying measurement devices were then tried out in a series of formal preliminary experiments. The findings in each case provided the basis for a more precise behavioral analysis, a refined instructional sequence, and a more adequate set of psychometric measures. A final study was then conducted in each of the three subjects areas. The design of each of the final studies was influenced by the unique characteristics of the subject matter involved and the findings of all of the preliminary experiments.

An attempt was made to record as carefully as possible the rationale for each modification introduced into an experiment. Subsequent chapters in this report describe the progress of this research. The experiments are reported as nearly as possible in the chronological sequence in which they were performed. Chronological organization was chosen in an attempt to record the sequence by which our behavior as researchers was differentiated en route in the project.

The remainder of this report should make it clear that our initial understanding of the problem, like that of our colleagues, was incomplete and our suggestions for solving it oversimplified. On the basis of our research findings we feel that whereas then "we saw through a glass darkly," we now "see face to face" (Paul, ca. 59). But this feeling of limited omniscience is now accompanied by an equally strong expectation that our future research work, and that of our colleagues, will quickly render this present conception similarly obsolete.

Thus, it is only the formal requirements of the situation which warrant titling this report "final." In the sense of fulfilling the research requirements of the grant award, the work can be considered more than complete. In the sense of accomplishing the research objectives of an instructional program of demonstrated absolute efficiency, the work must be considered as "in progress."

CHAPTER II

PRELIMINARY EXPERIMENTS

Preparation of Experimental Material

Initial Behavioral Analyses

The analysis in each of the three areas began with a behavioral specification of the terminal behavior. The selected areas were amenable to operational specification without undue difficulty:

Capitalization-to capitalize words in context in accordance with accepted English usage.

Fractions-to add and subtract common fractions.

Punctuation-to insert punctuation marks in unpunctuated context in accordance with accepted English usage.

Although this global definition of terminal behavior was a necessary first step, it was a very short step. From a psychometric point of view, it put us in position to prepare a proficiency measure of terminal behavior. From an instructional point of view, it faced us in the right direction. However, it provided only the most general cues concerning how to achieve the objective. Instructors who feel they "have it made" after defining an instructional objective in behavioral terms are bound to be disappointed; their work has just begun.

To generate a first approximation in breaking down the global response class we consulted available textbooks, curriculum guides, and courses of study. This informal content analysis yielded a logical and commonly utilized sequence of topics. In the areas of Capitalization and Punctuation we relied heavily upon research by Odom (1961). Odom's agenda was to determine the grade level required to attain the arbitrary criterion of at least 50 per cent of the pupils at a grade responding correctly to two of the four items used to measure the skill, but less than 75 per cent responding correctly to three of the four items. Although Odom's study was intentionally norm rather than criterion referenced, it at least provided an empirically derived indication of the relative difficulty of the topics as conventionally taught.

Tables 1-3 list in sequence the topics selected for inclusion in the original programs.

Preparation of Criterion Achievement Tests

For Capitalization and Punctuation the subtests (L2 and L3) of the *Iowa Test of Basic Skills* (Lindquist and Hieronymus, 1955) were selected as the criterion instruments.

The ITBS is based on overlapping coverage of items for each grade. However, for experimental purposes it was decided to have the pupils respond to all 102 items to include items at every grade level. These tests were chosen since the content analysis of each of the programs and that presented in the Manual for the tests indicated that all of the topics in the programs were adequately covered in the tests.

Use of a standardized test was thought desirable to provide a standard that would reflect the adequacy of the programs against norm referenced performance; i.e., against proficiency standards obtained in "traditional" instruction. The only frailty of the tests noted at this time was the fact that several additional topics were sampled in the tests that were not included in the terminal objectives of the programs.

In the area of fractions, no standardized test could be located that included a sufficient number of items to provide adequate reliability or content validity. A proficiency test of 41 items was therefore constructed containing algorisms involving the addition and subtraction of fractions.

Preparation of Initial Programs

A linear programmed sequence was developed in each of the three areas. The unique characteristics of each program are described below in connection with the experiments in which they were used. The difficulty and readability of vocabulary of each program were controlled. Children reading at a beginning 4th grade level should have encountered no reading difficulty, since more than 95 per cent of the words used were included in the Dale List of Familiar Words (Dale and Chall, 1948), and most of those outside the list were terms

TABLE 1

Experiment 1 - Capitalization Program Unit Topics

1. First word of a sentence
2. Name of a person
3. Initial of a person
4. The word "I"
5. Name of a pet
6. Days of the week
7. Names of the months
8. Names of holidays
9. Names of places
10. Names of titles
11. First word in a line of poetry
12. Titles of books
13. Names of nationalities and proper adjectives
14. Abbreviations of titles, steeets, etc.
15. Parts of a letter
16. Sections of our country
17. Direct quotations
18. Outlines
19. The word "O"
20. Mother, Father

TABLE 2

Experiment 2 - Fraction Program Unit Topics

1. Definition of fraction and whole number
2. Definition of numerator
3. Definition of denominator
4. Discrimination: numerator and denominator
5. Definition of proper fraction
6. Definition of improper fraction
7. Discrimination of proper and improper fraction
8. Definition of mixed number
9. Adding of like fractions whose sum is less than 1 (and requires no reducing)
10. Subtracting the same
11. Adding a whole and a mixed number
12. Subtracting the same
13. Subtracting fractions whose difference is 0
14. Changing the terms of a fraction (including definition of the word "terms")
15. Identifying which of two fractions is larger or smaller
16. Changing whole number to improper fraction
17. Changing mixed number to improper fraction
18. Subtracting like fractions involving decomposition but no borrowing
19. Changing improper fraction to whole number
20. Adding simple fractions whose sum is 1
21. Adding three simple fractions whose sum is 2
22. Reducing to lower terms when numerator is the divisor in the reducing process
23. Adding and subtracting fractions whose sum or difference requires reducing as described in (22)
24. Reducing to lower terms when numerator is not the divisor in the reducing process
25. Reducing to lowest terms
26. Adding like fractions whose sum requires reducing and is less than 1
27. Adding like fractions whose sum requires changing an improper fraction to a whole number
28. Changing an improper fraction to a mixed number
29. Adding like fractions whose sum requires changing an improper fraction to a mixed number

TABLE 3

Experiment 5 - Punctuation Program Unit Topics

1. Period - end of sentence
2. Question mark
3. Comma - city and state
4. Comma - date and year
5. Comma - greeting of friendly letter
6. Comma - closing of letter
7. Colon - greeting of business letter
8. Form of letter
9. Apostrophe - contraction
10. Period - initials and abbreviations
11. Underline - titles
12. Exclamation point
13. Comma - series
14. Quotation marks - titles
15. Comma - postal zone and state
16. Comma - month and year
17. Comma - state (or province) and country
18. Comma - appositives
19. Apostrophe - possessives
20. Comma - interrupting words and phrases
21. Comma - contrasting phrases
22. Comma - initial yes, no, well, oh, etc.
23. Comma - direct address
24. Comma and quotation marks - direct quotations

such as underline, sentence, denominator, etc., which were strengthened in the program.

Each program was arranged for presentation as a programmed text and tried out with from 5-10 individual subjects in a one-to-one setting in the Classroom Learning Laboratory. This pilot work proved useful in identifying technical deficiencies in each of the programs. Each program was revised extensively on the basis of these individual "field tests."

The results of the individual testing were spectacular, deceptively spectacular, as we were later to discover. Pupils manifested a very low error rate on the program and near perfect performance on the post-program parts of the criterion tests that were relevant to the instruction they had received. Thus the programs were judged ready for use in formal experimentation.

Preliminary Experiment 1 - Capitalization

The Capitalization program was arbitrarily selected as the instructional vehicle for the first experiment. The purpose of the experiment was to "validate" the instructional adequacy of the program and to try out the general experimental procedures.

Programmed Text

The programmed text was composed of 276 constructed-response frames presented in a linear mode, one frame to a page, with the correct response on the reverse side of the page. The pages were bound into three booklets of approximately 90 items each. An additional booklet of supplementary panels accompanied the program. As previously described, the content corresponded to the material conventionally presented in English texts used with third to eighth grade pupils. Designed to teach a child to capitalize words in accordance with standard English usage, the program presumed no grammar repertoire.

Subjects

Pupils in two summer session classes of the Arizona State University Campus Laboratory School were subjects in the experiment. The 17 fourth-grade pupils in one class had just completed the third grade; the 19 fifth-grade pupils in the other class had just completed the fourth grade. The pupils were attending summer school for a variety of reasons and varied widely in terms of general ability and level of achievement.

Procedure

The Capitalization Subtest (L2) of the *Iowa Test of Basic Skills*, Form 2 was administered as a pretest the first day of the experiment. Pupils were instructed to respond to items at all grade levels of the test. Only the fourth and fifth grade levels of the test, however, were scored for each class respectively.

On the second day of the experiment the pupils were instructed how to use the programmed text by means of a specially prepared set of 21 frames titled "How to Use a Teaching Machine Book," to which the pupils responded item by item under the direction of the experimenter.

On the third day each pupil was given the first booklet in the program and was allowed to proceed at his own rate. Pupils received no other formal instruction in English usage, grammar, etc., during the period the experiment was in progress.

A teacher was available to answer questions concerning reading and spelling and to assist pupils who experienced procedural difficulties. Teachers were instructed not to give direct answers to questions relating to the content of the instructional material.

Form 1 of the Capitalization Subtest (L2) of the *Iowa Test of Basic Skills* was used as the criterion posttest which was administered to each pupil individually the day after he completed the last item in the programmed text. Subjects thus served as their own controls in a direct-difference design.

Results

Table 4 presents the pretest and posttest results for each group. The raw scores have been converted to grade equivalents using the conversion tables accompanying the test. The increase in the means for the group entering fifth grade is significant at the .01 level ($t=3.39$), while the difference for the group entering fourth grade, although also in the direction of gain, is not statistically significant (t=1.89).

Table 4

Descriptive Statistics for Criterion Measures

	Grade 4		Grade 5	
	Mean	S.D.	Mean	S.D.
Pretest	4.3	1.5	5.9	1.5
Posttest	4.8	1.5	7.2	1.3
Difference	0.5		1.3	

The total time spent on the program ranged from 11 to 16 days (5½ to 8 hours total working time). Three entering-fourth-grade pupils who did not completely finish the program by the end of the sixteenth day were given the posttest on the seventeenth day. The total errors on the program ranged from 9 to 111 in the fourth grade with a median of 27, and from 1 to 94 in the fifth grade with a median of 10. The rank order correlation between total number of errors on the program and gain on the posttest is -.13 in the fourth grade, and -.43 in the fifth grade.

Evaluation of Results for Further Revision

At face value, one would interpret the results of the study as indicating that the program was clearly effective in the fifth-grade class but was less clearly effective in the fourth-grade class. To conclude that a self-instructional program is effective is to say that pupils completing the program acquire the behavior the program seeks to develop. A statistically significant t-value, however, indicates only that there is a reliable difference in average performance on the pretest and posttest--not that all pupils performed adequately on the posttest. The magnitude of the posttest standard deviation of each group shows considerable varibility in performance. Some pupils performed far above average, some far below. Inspection of the gains made by individuals shows the same variability. Some pupils gained much, others gained little.

Although data show unequivocally that the program worked extremely well for some and failed to accomplish its objective for others, we still were at a loss to know just what overall instructional effectiveness the program had. As is customary in standardized testing, the ITBS assigns items to certain designated grade levels. Thus, students in, say, the fourth grade respond to only 39 of the total 102 items, yet they have completed the same instructional tasks as a seventh grader who responds to a different set of items at a different grade level designation. If the interest is to estimate gain using an absolute criterion, the measurement device used as the criterion must include adequate item sampling representing the entire range of behavior and content included in the instructional material. In the next study it was decided to score the full 102 item test, so performance can be described in terms of the total capitalization universe, as well as in terms of the norm referenced criteria.

Ultimately, of course, measurement technology must aid instructional technology in making precise and reliable decisions concerning student performance. Establishing norms and correlating performance with grade levels and intelligence serves to mask the more troublesome instructional issues. Describing a pupil in terms of IQ and grade-level achievement certainly leaves an instructor in limbo when one asks the question, "With a grade placement score of 5.3, what specifically can the pupil do?", or, "Why didn't my youngster learn it all?"

Prerequisite for revising the program, the question was posed as to why the capitalization program did not work for everyone. To answer this question one might look (1) to error-rate on the program and (2) to characteristics of individual responses and and response patterns. Error-rate proves to be a poor indicator of the effectiveness of programmed instruction. The error-rate of 10 per cent in the fourth grade and 4 per cent in the fifth grade is quite respectable in terms of current standards, yet many pupils did not attain the instructional objective.

Analysis of individual responses and response patterns suggested several hypotheses for testing in subsequent experiments.

First of all, the program included some ambiguous, misleading, or otherwise faulty items. These are easily recognized since a large proportion of the pupils ran into difficulty at the same places. These items needed to be rewritten or modified.

Secondly, many children seemed to handle the capitalization-performance items in the program quite well but failed to acquire the rules which state or explain the reasons for capitalizing words. Individual posttest results indicated that children who failed to learn those rules also failed to gain on the achievement criterion.

This apparent relationship suggests that rules may be important mediators of capitalization performance; unless the pupil has learned them, capitalization skills shaped previously in the program will be weak in subsequent novel situations. However, as developed in this program, rules probably constituted a response class different from the capitalization responses per se. We decided to explore the relationship between the rules and capitalization responses more fully in subsequent studies.

Last, although the program assumes little in terms of previous information, it does require the pupils to read the controlled vocabulary and write the constructed responses. These incidental behaviors were not in the repertoire of several fourth-graders and one or two fifth-graders, most of whom were attending summer school because of recognized deficiencies in reading. Too, some youngsters who could read had difficulty with a few of the topics because they did not have specific labels in their repertoire. For example, one needs to know the names of a certain number of towns or places in order to respond to the eliciting cues in the programs. At least a few children in the typical classroom could be expected to encounter the same kinds of reading difficulty.

In summary, the major implication of the first capitalization preliminary study relates to the perennial educational problem of the interdependence of achievement.

Preliminary Experiment 2 - Fractions

This experiment was designed to cross-check the findings of the first experiment in a different subject matter area and with a fresh sample of pupils.

Experimental Materials

Programmed Text. A linear sequence of 1320 frames was prepared. This program was the final product evolving out of three pilot studies involving field tests of the material on four classes in grades 4, 5, and 6; and 14 individual pupils in the Laboratory. In addition to providing data for sharpening individual frames and improving the short-term sequencing, the pilot data were instrumental in increasing the precision with which the terminal behavior and its contents were specified. These components were finally arranged in the sequence of 29 identifiably different response classes listed in Table 2.

A comparison of the first edition of the program with that used in the present experiment indicates the manner in which more sophisticated analytical treatment of the subject matter resulted in the identification of discrete units designed to shape a much narrower and more specific class of responses. For example, success in the simplest type of fraction-adding (Unit 9, adding like fractions whose sum is less than one and requires no reducing) is dependent in this program upon S's possessing the ability to discriminatively tact: (1) fractions, whole numbers, and mixed numbers; (2) numerators and denominators; and (3) proper and improper fractions. Tacting of these terms is prerequisite to success not only in Unit 9, but also in subsequent units involving computation. Thus, the 29 units of the program were used systematically to build the later structure. Both the identification of the components and the sequencing represent a departure from the analysis of the learning task found in arithmetic textbooks and in those programmed texts which were available at the time of this revision.

The 1320 frames were spirit duplicated on 8½" X 11" and arranged into a programmed text of 10 books of approximately 60 pages each.

The correct response for each frame appeared on the page following the frame.

Readiness Test. A Fraction Readiness Test of 42 items was constructed to measure competence with respect to the arithmetic manipulation of whole numbers and the texting of the general content of the instructional sequence. This test is reproduced in Appendix A.

Criterion Achievement Tests. Two 50-item criterion achievement tests, directly parallel in terms of content, were prepared to use as pre- and post experiment measures of the program. One form of the test is reproduced in Appendix B.

Unit Tests. Parallel pre- and posttests were prepared for each of the 29 units listed in Table 2. These were brief tests of four to ten items each. Each test was designed as a direct measure of proficiency with respect to the behavior of interest in the unit.

Design

Subjects. One hundred twelve pupils enrolled in 4 fifth grade classes in a suburban elementary school district participated in the study. Thirteen were eliminated from the experiment because their scores on the Fraction Readiness Test indicated they were in need of remedial help before they could be expected to achieve the self-instructional objectives. Although they were permitted to work on the instructional materials for the convenience of the classroom teacher, their results were not included in the analysis. Fifteen pupils, randomly selected, were not included in the analysis of data to obtain groups of equal size for computation convenience.

Treatment Variations. A Pretest-Posttest Control Group Design (Campbell and Stanley, 1963) was utilized. One-third of the pupils in each class were randomly assigned to one of each of the following three treatments:

1. Program With Bypassing. Each S's progress through the instructional program was predicated upon his Unit Test performance. Three contingencies were possible: (1) bypassing

the unit instruction following adequate Unit Pretest performance, (2) responding to the unit instruction following inadequate Unit Pretest performance, (3) repeating the unit instruction following inadequate Unit Posttest performance.

2. Program With Non-contingent Unit Tests. Ss in this group responded to the Unit Pre- and Posttests in the same fashion as Ss in Treatment 1. The Unit Tests, however, were not scored; Ss continued with the program irrespective of their Unit Test performance.

3. Program Without Unit Tests. Ss in this treament responded only to the programmed text. All reference to Unit Tests was deleted from the program.

The experiment was scheduled to coincide with the school system's regular instruction in the addition of like fractions to insure curricular continuity and to avoid artificiality of a novel and ill-fitting supplement to the curriculum. All testing and instructions were handled by the regular classroom teachers.

Procedure

The Readiness Test and Criterion Pretest were administered to all Ss approximately 10 days prior to the experiment. The day before beginning work on the programmed text all Ss were instructed concerning its mechanics by means of a 35-frame sequence, "How to Use a Programmed Text." From the time they completed this preliminary instruction until they completed the fraction program, Ss worked independently on the program for approximately 40 minutes daily. Teachers were instructed to offer no assistance beyond help with obvious procedural difficulties. In Treatment 1, teachers scored the Unit Posttests as the pupils completed them, but the teachers were instructed to do nothing but check the appropriate contingency without comment regarding S's performance. Time spent on the program each day was recorded by the teacher.

On the day following completion of the final unit, each S took the Criterion Posttest.

The effects of the three experimental treatments on instructional time and achievement were compared in two single-classification analyses of covariance. Covariates in each analysis were Criterion Achievement Pretest, Kuhlmann-Anderson IQ based on an administration of the test earlier in the year in the school's regular testing program, and the Fraction Readiness Test.

Results and Discussion

Table 5 shows the descriptive statistics for each of the three treatment groups on the covariates and criteria. The analyses of covariance indicated no significant difference among the groups with respect to posttest performance (F=1.44). The difference in time spent on the program is significant at the .05 level (F=4.02). Table 6 shows the adjusted mean scores and the resulting F values.

The interpretation of these overall comparisons is complicated by several variables which differentially affected the behavior of Ss in the three groups. The time difference favoring Treatment 3 is in large part a function of the smaller number of responses required of Ss in this group. If the 303 unit test items which these Ss did not take were considered as program frames, the length of the program would be increased by 23 per cent. A 23 per cent extrapolation for Treatment 1 would result in a mean response time of 819.2 minutes, which is directly comparable to that of Ss in Treatment 1.

Treatment 1 Ss did do a good deal of bypassing. The number of units skipped ranged from 0 to 23 with a mean of 13.31 and standard deviation of 4.07. This finding indicates that the experimental Ss did differ in terms of their instructional needs and suggests that bypassing may have potential in handling these individual differences.

Moreover, the bypassing Ss performed significantly better on the unit achievement tests than the non-bypassing Ss. The mean cumulative errors on the unit tests was 15.33 for Treatment 1 with a standard deviation of 10.3 compared to a mean of 44.46 and standard deviation of 27.6 for Treatment 2. This represents a typical performance of approximately 95 per cent correct responses in

TABLE 5

Means and Standard Deviations for Covariates and Criterion Variables, by Treatment

Treatment	Covariates						Criteria			
	IQ		Readiness		Pretest		Posttest		Time (minutes)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1 Program-Bypassing	107.32	13.20	39.11	2.82	7.82	5.21	31.50	10.00	818.6	231.1
2 Program-Non Bypassing	112.46	12.78	38.11	3.04	8.28	4.67	31.78	11.47	799.8	229.0
3 Program Only	112.50	9.30	39.67	1.76	9.71	6.02	32.36	11.84	638.6	160.4

TABLE 6

Adjusted Means and Resulting F Values for the Fraction Criterion Achievement Test and Time Spent, by Treatment

	Adjusted Means	
	Criterion Test	Time
1 Program-Bypassing	33.62	808.0
2 Program-Non Bypassing	31.24	784.9
3 Program Only	30.43	666.0
F	1.44	4.02
P	NS	<.05

Treatment 1 compared with 85 per cent in Treatment 2. Informal observation indicated that the bypassing pupils quickly discovered their progress in the program was contingent upon performance on the Unit Pre- and Posttests, and consequently worked slowly and carefully on these tests. Non-bypassing pupils, on the other hand, tended to treat the unit tests and the instructional frames in much the same way.

This differential performance of bypassing and non-bypassing pupils indicated that the program was succeeding with respect to acquisition of the desired behavior. However, it lacked the nececsary contingencies to maintain the behavior in strength until the final achievement posttest. This suggests that increased attention must be given to cumulatively reinforcing the response class of interest--behavior reflected in the final criterion test.

Altogether, the results suggest that bypassing does have potential for meeting individual differences in self instruction despite the fact that the experimental procedures failed to take full advantage of the potential. The Unit Tests incorporated into the program proved to exert strong control over program behavior. However, Ss were even more sensitive to differential reinforcement contingencies than was anticipated prior to the study. Unfortunately, these contingencies were not totally consistent with the overall instructional objectives. Subsequent studies attempt to eliminate this discrepancy.

In addition to their influence on pupil behavior, the Unit Tests proved extremely useful in identifying deficiencies in the instructional program frames. Although the program had undergone numerous revisions prior to the experiment, it still proved to have several weak spots which had not been revealed using error rate criteria. Most of these related to over-cueing. Overcued sequences are likely to appear quite adequate in terms of error rate. However, when the cues are removed in an external achievement test, the deficiency becomes quickly and painfully obvious.

Several other findings and inferences relating to general programing strategy were common to both the present experiment and to Experiment 1-Capitalization. Of particular importance for the revision of the capitalization program was that both preliminary studies reflected low mean error rates in the programs themselves, yet both obtained something less than absolute performance on the final criterion tests.

The inference was made that acquisition of the desired behavior had taken place, but the behavior apparently was not maintained in strength sufficient to insure comparable results on the final post-experiment criterion test. The capitalization program did contain numerous review frames regularly interspersed throughout. However, there was no special reinforcement to these items. In the case of the fractions study, which was already broken into units, the important reinforcement contingency was passing the Unit Test and bypassing the next unit. The implication is that greater attention must be paid to maintaining acquired behavior and shaping final criterion behavior as a global response class.

Preliminary Experiment 3 - Capitalization

On the basis of the findings of the first two experiments the Capitalization program was completely reworked. Aside from technical revision of individual frames based on an analysis of pupil responses, the revision was designed to accomplish two ends.

First, the learning of capitalization rules was treated as an identifiable response class. This was done by designing frames to shape tacting (rule) responses and interspersing them with frames designed to shape responses for which the tact could function as a significant discriminative stimulus.

Second, a number of review and generalization frames were added in an attempt to insure that the acquired behavior would be maintained and extended to a greater variety of situations involving capitalization. This achieved a further technical programing benefit in that it served to break up response sets inherent in the homogeneous response class represented by each of the units. This homogeneneity provides undersirable prompts and permits a pupil to learn nothing more than to perseverate the same response under every condition.

The present experiment was designed to serve two purposes. First, empirical data concerning the classroom functioning of the revised instructional sequences and accompanying tests were required.

Second, the experiment investigated the problem of acquisition _vs_. maintenance of behavior. An attempt was made to treat the two processes separately. Instead of attempting to build into the program itself all of the maintenance frames, short nine to fifteen item "review exercises" were constructed to be completed by the S as soon as he had finished the appropriate unit in the program. Thus, the program was developed to deal primarily with acquisition, leaving maintenance to the Review Exercises. A sample Review Exercise is shown in Appendix C. Systematic variations were introduced into the experiment with respect to the reinforcement contingencies associated with Review Sheet performance.

The results of the first two experiments indicated that pupils were extremely sensitive to the relative reinforcement contingencies in a program. Since the behavior of greatest relevance to final criterion performance was thought to be reflected in the Review Exercises, it was decided to differentially reinforce Review Exercise performance. To standardize the experimental control, an extrinsic reinforcer in the form of trading stamps was utilized.

Experimental Materials

Programmed Text. Table 7 shows the sequence of 19 units in the revised program expressed in content terms. Note that of the original 20 topics only "capitalization of the word 'O'" was eliminated. This was done because of the lack of generalizability of this specific skill. The 555 frames were spirit duplicated on 8½" X 11" paper and arranged into programmed texts of two books of approximately 100 pages each. The correct response for each frame appeared on the page following the frame.

Readiness Test. Two kinds of entering behavior were identified as prerequisite to success with the program. The first is sufficient skill to read (text) the program content. The second is an ability to tact various words used in the program as members of designated stimulus classes. For example, unless a pupil can discriminate the names of states from words that are not the names of states he has little chance of capitalizing such terms correctly.

To measure these two skills a Readiness Test of two parts was constructed. To prepare Part I, 25 of the most difficult words in the program were selected by inspection. Each was then used as the keyed response in a "vocabulary" test. Part II requires the examinee to discriminate the members of various word classes by responding "member" or "not member" to a list of S+ and S- stimuli. The test is reproduced in Appendix D.

Criterion Achievement Tests. Forms 1 and 2 of the Capitalization Subtest (L2) of the Iowa Test of Basic Skills were again used as the criterion instruments. In addition, a modified Form 2 of the test was also developed. This modification followed from the analysis

TABLE 7

Capitalization Program Topics and Number of Frames

Topic	Frame Numbers
1. Discrimination: capital and small letters	1-25
2. First word of sentence	26-55
3. Name of person	56-90
4. Initials	91-111
5. The word "I"	112-144
6. Name of a pet	145-166
7. Days of the week	167-183
8. Names of months	184-212
9. Holidays	213-232
10. Places	233-279
11. Titles	280-314
12. First word in line of poetry	315-328
13. Book titles	329-354
14. Nationalities and proper adjectives	355-385
15. Abbreviations: titles, streets, etc.	386-403
16. Parts of a letter	404-449
17. Sections of our country	450-479
18. Direct quotations	480-522
19. Relationships	523-555

of individual response patterns on the *ITBS* in the first capitalization experiment. Ss seemed to have a strong propensity for marking position four, "no mistakes," far more frequently than chance or sampling would have estimated. It appeared that position 4 provided an "easy way out" of a difficult discrimination. The sample items below indicte the strategy used to eliminate the "no mistakes" stimulus. On the left is the item as it appears in Form 2; on the right is the modified item as it appears in Criterion Achievement Test C:

Actual Item	Modified Item
1) My kitten tries to follow	1) My kitten tries to
2) me when i go upstairs, but	2) follow me when i go
3) she can't climb the steps.	3) upstairs, but she can't
4) *no mistakes*	4) climb the steps yet.

In general the item sampling of the test remained the same. However, to balance the attractiveness of distractor position, the content of a few items was altered slightly to make distractor four an error position.

Unit Tests. A pretest and a posttest for each unit were constructed. These tests were designed to sample the behavioral objective being shaped in a given unit. Each test ranged from 6 to 18 items in length. For the most part, the items were two-choice discriminations of correct and incorrect capitalization in single sentence context. However, constructed response items were also included in a few of the tests. All of the Unit Tests were included in a single booklet separate from the programmed text. Pretest keys were included at the back of the test book for pupil scoring.

Review Exercises. The general nature of the Review Exercises has been described above. A sample Review Exercise is shown in Appendix C.

Design

Four different instructional treatments were investigated:

1. Program
2. Program + Review Sheets
3. Program + Review Sheets + Extrinsic Reinforcer

Two hundred seventy pupils enrolled in 8 fourth, fifth, and sixth grade classes of a single elementary school participated in the experiment. Because previous experimental experience had demonstrated that more than one treatment in a classroom is inordinately demanding of the teacher and disruptive of class routine, each class was randomly assigned to one of three treatments at grades 4 and 5. At grade 6, one class was randomly assigned Treatment 1 and the other Treatment 3. Unfortunately, the entire set of final Criterion Achievement Test answer sheets for the Treatment 1, fourth grade class, was lost somewhere between the teacher's room and the principal's office and apparently disposed of by mistake. This class was therefore "lost" for data analysis purposes. Loss of data for random reasons, we learned, is a dangerous hazard of experimentation in a natural school setting, irrespective of the precautions established to prevent it.

Procedure

All classes were given the Readiness Test the first day of the experiment, the ITBS, Form 2, the second day, and "How to Use a Programmed Text" the third day.

Each pupil worked on the instructional program at his own pace. The procedures and mechanics of the instruction were similar to those used in the Fraction Experiment 2. For each unit, a pupil first took and scored a Unit Pretest. If he missed two or more, he was directed to "go to page--" of the program and work through the programmed text. If he missed one or none, he was directed to take the Unit Posttest. The teacher scored the Unit Posttest and checked the appropriate instructions for continuing. If the pupil missed one or none on the Unit Posttest, he was allowed to bypass the program unit and was directed to complete the Unit Review Exercise. If S worked through the program unit and still failed the Posttest, he was directed to retake the program unit once more before proceeding to the Unit Review Exercise.

Unit Review Exercises were picked up daily by E, scored at the Laboratory, and returned the following day with errors and total score indicated. In the Extrinsic Reinforcement treatment groups, 10 trading stamps were dispensed for a perfect Review Exercise and one stamp deducted for each error. Gold Bond Stamps, widely used locally, were used. Stamps were dispensed by the teacher at the time she returned the Review Exercises to the pupils. Each child was provided a book in which to paste his stamps.

The ITBS, Form 1, was administered to each pupil individually the day following his completion of the last unit.

Findings

Despite the fact that the emphasis in this project is on evaluating programs and contingencies on the basis of content referenced criteria, let us consider the data from a norm referenced point of view. Table 8 illustrates the dramatic effects accrued when evaluating progress using a norm referenced criterion. The table presents the pretest (Form 2) and posttest (Form 1) results for the two classes of grade 4 when their performance is compared to third, fourth, and fifth grade norms. The raw scores have been converted into grade equivalents using the conversion tables accompanying the test.

TABLE 8

Grade 4 Mean Grade Equivalents for Criterion Pretests and Posttests, Based on National Norms

	Grade 3 Norms			Grade 4 Norms			Grade 5 Norms		
	Mean	S. D.	P.	Mean	S. D.	P.	Mean	S. D.	P.
Pretest	5.4	.5		5.5	.6		5.6	.7	
Posttest	6.2	.6		6.9	.7		7.6	.9	
Difference	+.8		$<.01$	+1.4		$<.01$	+2.0		$<.01$

The achievement gain in each case is statistically significant beyond the .01 level. The differences are also sufficiently large in terms of grade progression to have considerable "practical" significance. However, from an absolute point of view this spectacular success is highly misleading, rather than highly significant.

TABLE 9

Means and Standard Deviations for Covariates, Criterion Tests, Units Bypassed, and Units Repeated, by Grade

	Readiness I		Readiness II		Criterion Pretest		Criterion Posttest		Modified Posttest		Number Units Skipped		Number Units Repeated	
Grade	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
4	21.26	3.17	13.03	2.80	57.81	12.96	65.56	14.82	73.91	18.18	5.31	2.99	.60	.95
5	21.78	2.76	13.13	2.54	67.13	12.90	72.78	12.58	75.72	14.87	7.28	3.20	2.12	2.14
6	22.34	2.61	14.65	2.79	66.45	13.18	73.31	15.65	79.22	15.10	10.00	1.79	.24	.71

Table 9 shows the descriptive data for grades 4, 5, and 6, for the Readiness Tests, Criterion Tests, number of units bypassed, and number of units repeated. The table shows that grade 4 entered the experiment considerably more naive than either grades 5 or 6. However, grades 5 and 6 differed very little. Grade 4 is again considerably below grades 5 and 6 on the ITBS Posttest. Interestingly, though, when the modified criterion performance is taken into account, only 5 points separate grades 4 and 6, with grade 5 splitting the difference.

Another important finding is reflected in Table 9. Unit bypassing did occur. Grade 4 skipped a mean number of 5.31 units. The distribution is negatively skewed with a S.D. of 2.99 units. Grade 5 skipped an even larger number of units (7.28) than Grade 4, skipping over half of the program, but in so doing repeated a mean of 2.12 units. It may be that the fifth graders entered the program with a false sense of mastery. The fact that many of the units were "old hat" may have cued occassional lapses of close program attention behavior which left them somewhat short of unit mastery. It is likely that the sixth graders' Capitalization repertoires were sufficiently strong to tolerate a more casual approach to the program assignments.

Tables 10 and 11 show the adjusted mean scores and resulting F values from analyses of covariance of the ITBS Test B with the Readiness Tests and Criterion Test A as the covariates. Tables 12 and 13 show the results when Criterion Test C is similarly analyzed.

Table 10

Adjusted Mean ITBS Posttest Scores and Resulting F-Values for Treatment, by Grades

	Grade		
Treatment	4	5	6
1. P		72.06	71.65
2. P + R	64.18	72.08	
3. P + R + GB	66.86	73.11	69.74
F	1.30	.16	.70
P	NS	NS	NS

Table 11

Adjusted Mean ITBS Posttest Scores and Resulting F-Values for Grades, by Treatment

		Grade			
Treatment	4	5	6	F	P
1. P		73.41	72.59	.18	NS
2. P + R	72.31	70.26		.51	NS
3. P + R + GB	75.21	66.38	67.81	3.26	.05

Table 12

Adjusted Mean Modified ITBS Scores and Resulting F-Values for Treatment, by Grades

		Grade	
Treatment	4	5	6
1. P		74.81	80.69
2. P + R	69.19	75.45	
3. P + R + GB	78.35	76.05	78.44
F	6.22	.09	.60
P	.05	NS	NS

Table 13

Adjusted Mean Modified ITBS Scores and Resulting F-Values for Grades, by Treatment

		Grade			
Treatment	4	5	6	F	P
1. P		75.47	81.59	6.76	.05
2. P + R	77.48	74.60		.41	NS
3. P + R + GB	80.62	69.59	72.36	5.56	.01

Table 10 shows that within each grade the treatment variations had no significant differential influence. Table 11 shows that only Treatment 3 had differential effects in the three grades. The F of 3.26 indicates that Grade 4 found the additional reinforcement in the way of Gold Bond Stamps differentially beneficial. Grade 4 had had little formal capitalization training prior to the experiment, whereas both grades 5 and 6 had had varying amounts of formal instruction.

Inspection of Table 12 shows that eliminating the chance for the student with a weak response to plead "no mistake" on the criterion test changes the influence a specific treatment appears to have. The obtained F of 6.22 demonstrates that additional reinforcement external to the program and related to the Review Exercise was clearly more effective at the fourth grade level. Again, the different treatments in the fifth and sixth grades had little differential effect.

Table 13 shows that Program + Review treatment behaved similarly in both grades. This result held for the modified ITBS Criterion also. Neither did the Program + Review treatment have an effect significantly different from that of the Program Only treatment. Apparently, the Review Exercise alone is not a worthwhile addition if other controlling contingencies are not altered. The significant difference between grade 5 and 6 in Program Only might indicate that the more experienced sixth graders are able to progress without the additional maintenance and extension provided by the Review Exercises.

The obtained F of 5.56 for grades 4-6 in Treatment 13 (Table 13) is significant beyond the .01 level. Further analyses indicate that the differences between grades 4 and 5, and between 5 and 6, are significant at the .01 level. This is additional support for the point suggested earlier that the various reinforcement contingencies operate more sensitively with pupils who have fewer of the programmed behaviors in their repertoire.

Evaluation of Results for Final Revision

Although absolute criteria provide the most justifiable base for evaluating the effects of programmed instruction, traditional classroom conditions make such an enterprise difficult if not impossible. Individual differences at entry are so great, and the controlling contingencies so patterned, that the course of least resistance is to employ a "relative" statistical design and hope for a sample of students who are maximally naive with respect to the material, but at the same time are above the minimum level of prerequisite behavior for program entry. The results indicated that in the face of the various odds and gods, grade 4 students constitute the most suitable experimental population for further investigation of the Capitalization program.

Both the Review Exercises and the reinforcing contingencies surrounding their use appear to warrant further investigation. The mechanics of the Gold Bond Stamps were handled without any difficulty. Their use appeared to have a much greater effect on our professional colleagues than on school personnel, parents, or pupils. We received no aversive feedback whatsoever from the schools. However, we were very careful to make it clear to all concerned that the stamps were being used for purposes of experimental control only.

The study also yielded useful information concerning the pre- and post-experiment criterion measures. Although modification of the scoring scheme improved the content validity of the ITBS Capitalization Test, it sill was not totally acceptable as a direct performance measure of capitalization skills. Albeit, the vocabulary level and content coverage were quite satisfactory. The major remaining criticism was that each item forces S to make but one direct discrimination, i.e., correct vs incorrect. Rather than being a direct measure of ability to capitalize correctly, it is a direct measure of finding a single error. The criterion measures for the final study were revised to sample more adequately the specific behaviors the program was attempting to shape. The nature of the modification is illustrated by two forms of the sample shown below:

1) My kitten tries to follow me
2) when i go upstairs, but
3) she can't climb the steps yet.
4) no mistakes

1. My $\overset{K}{k}$itten tries to follow $\overset{M}{m}$e when $\overset{I}{i}$ go

upstairs, $\overset{B}{b}$ut $\overset{S}{s}$he can't climb the steps yet.

Note that in the second format the S is asked to make five responses rather than one. In addition, the responses are controlled, hopefully, by simple or multiple discriminative stimuli related to the various rules for capitalization. Too, this type of item affords greater flexibility in sampling. For example, the item shown above samples three different units and two permutations of one.

S+	S-
I (the word I)	kitten (name of pet)
	me (personal noun related to "I", and name of person)
	,but (capitalize word following terminal punctuation)
	she (personal noun related to "I", and name of person)

Preliminary Experiment 4 - Fractions

This experiment was conducted concurrently with Experiment 3 - Capitalization. The experiment was designed to serve two purposes. First, empirical data were sought concerning the Fractions program at a grade level other than the one at which the instruction is traditionally given..

Second, the experiment investigated the effects of "Review Exercises" and extrinsic reinforcement on criterion achievement.

Experimental Materials

Programmed Text and Tests. The instructional program, Readiness Test, Criterion Tests, and Unit Tests were identical to those used in Experiment 1 - Fractions.

Review Exercises. A Review Exercise was constructed for each unit. The Exercises varied in length from 6 to 47 items, and included 595 items altogether. A slightly different sampling strategy was used in constructing the exercises from that used in Capitalization in that each exercise cumulatively sampled the content of preceding units. Appendix E shows a sample Review Exercise.

Design

Two different instructional treatments were investigated:

1. Program + Review Exercises + Extrinsic Reinforcer
2. Program Only

One hundred thirty-five Ss in 4 fourth grade classes participated in the experiment. Three of the classes received Treatment 1, while one class received Treatment 2. Only pupils who attained a score greater than 30 on the Readiness Test were included in the analysis. A total of 13 pupils failed to meet this pre-experiment criterion.

Procedure

Experimental procedures were directly analogous to those used in Experiment 3 - Capitalization.

Results

The descriptive statistics for the two treatment groups are shown in Table 14. Treatment 1 Ss achieved a mean score of 59% of the items correct on the criterion test, while control group Ss scored 43%. This compares with a mean criterion performance of 63% correct for all fifth-grade experimental classes in Preliminary Experiment 1 - Fractions.

TABLE 14

Descriptive Statistics for Treatment Groups

	IQ		Readiness		Achievement Pretest		Achievement Posttest	
Treatment	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	114.27	12.88	37.98	2.89	4.31	2.13	29.92	9.20
2	114.46	12.26	38.04	2.68	6.36	3.73	23.46	9.92

An analysis of covariance of the Achievement Posttest, using Criterion Pretest, Readiness, and Kuhlmann-Anderson IQ obtained from school records as covariates, yielded an F of 42.65, significant at the .01 level. Table 15 shows the adjusted mean Criterion Posttest scores and the resulting F.

TABLE 15

Adjusted Means for Criterion Posttest Scores by Treatment

Treatment	Adjusted Mean
1 Program + R + S^{R+}	30.70
2 Program Only	22.02
$F = 42.65$, $p < .01$	

Table 16 shows the means and standard deviations of the number of units bypassed and the number of units repeated by Ss.

TABLE 16

Descriptive Statistics for Units Bypassed and Units Repeated

	Mean	S.D.
Units bypassed	13.92	2.40
Units repeated	5.05	2.79

Table 17 shows the means and standard deviations of correct responses on the Review Exercises.

TABLE 17

Review Exercise Means and Standard Deviations

Unit	No. Items	Mean	S.D.	Unit	No. Items	Mean	S.D.
1	8	6.86	1.52	17	29	15.08	6.73
3	8	7.47	1.12	18	28	14.98	5.38
5	7	5.63	1.40	19	28	16.71	5.50
6	9	7.51	1.73	20	32	17.35	6.64
7	6	5.21	.99	21	27	14.10	5.51
8	8	7.02	1.49	22	29	14.02	5.54
9	8	6.98	1.38	23	28	14.39	5.34
10	15	12.90	2.42	24	28	12.64	5.69
11	21	18.33	3.27	25	28	14.13	6.86
12	19	17.38	2.40	26	27	14.40	6.75
13	18	15.49	3.03	27	30	18.61	7.39
14	23	18.02	4.75	28	44	20.53	11.34
15	20	15.19	3.38	29	47	20.57	11.52
16	20	11.34	3.98				

Performance on the items related to content of Units 1-12 is uniformly high, but less near an absolute criterion score on the later units of the program.

Evaluation of Results for Final Revision

The results of this experiment demonstrate that in terms of pupil readiness, fourth grade students as a group possess the prerequisite behaviors for success in the program. However, we also found that the realities of the traditional classroom militate against the advisability of using a fourth grade sample in the final Fraction Experiment. The task of any classroom teacher is to "get on with it." However interested the teacher is in educational innovation, she still finds it difficult to put up with the concommitant curricular disruption unless it is accompanied by a "payoff" other than "the interest of science." To minimize the effect of "irrelevant" contingencies which are difficult to assess and impossible to control, it was decided to use the fifth grade level as the population universe in the final experiment.

In the fifth grade, adding and subtracting common fractions is an ordinary part of the curriculum, whereas it is not in the fourth grade. Hopefully, helping the teacher with an assigned part of the curriculum will constitute a "pay off" sufficient to help us compete more favorably for student attention and general classroom control.

Since the design of the present experiment confounded the effects of the Review Exercises and the introduction of extrinsic reinforcers (Gold Bond Stamps), it is impossible to determine the relative effect of each variable on criterion performance. Since the combined effect significantly improved the efficiency of the total program, further exploration of the variables appeared to be in order.

Analyses of individual response patterns as well as inspection of mean score performances on the Review Exercises revealed that beyond Unit 13 a more systematic sampling procedure would be necessary. Apparently the increasing complexity of the response classes necessitates a more systematic cumulative process. Even though unit performance on the program indicates that the pupil has acquired the computational chains involved in the unit *per se*, care must be taken in subsequent Review Exercises to extend more systematically the more complex stimulus control.

Again the mechanics surrounding the use of an extrinsic reinforcer caused no dificulty. The Gold Bond Stamps appeared to be strong "motivators." However, the contingencies were such that the behavior they were reinforcing was global "trying hard" on the Review Exercises. That is, there were no immediate consequences for responses to the individual items; reinforcement was contingent only upon total score. The reinforcement was much too far removed from individual responses to exercise the precise instructional control we were seeking to establish.

Preliminary Experiment 5 - Punctuation

This was the first formal study performed with the Punctuation materials. The experiment was designed to serve two purposes.

First, empirical data concerning pupil responses to the instructional sequence and accompanying tests were required.

Second, further exploration of the appropriate utilization of "review exercises" was necessary. Previous preliminary studies had supported the general feasibility of successively approximating the population of responses defining the overall instructional objective. However, the practical logistics had proved complicated. This experiment investigated the effect of immediate knowledge of results for each Review Exercise response. Knowledge of results was communicated by using chemically pretreated answer sheets. Keyed response spaces were mimeographed with a specially mixed ink containing a red dye. The dye was not visible on an unmarked sheet but bled to show a color when dampened with a pen containing a water base solution (Appendix F).

Experimental Materials

Programmed Text. A linear sequence of 968 frames was prepared, divided into the 24 units shown in Table 3 on page 18. The frames were spirit duplicated on 8½" X 11" paper and arranged into a programmed text of three books of approximately 100 pages each. The correct response for each frame appeared on the page following the frame. The reverse side of each page was printed with a black screen to prevent the pupils from "peeking" at the correct responses prior to responding, a problem which had caused some difficulty in earlier experiments.

The brief sequence on using the programmed text described in connection with previous experiments was completed prior to the instruction.

Readiness Test. A test to assess entering behavior with respect to reading skill was prepared. Insofar as possible the instructional program was written at a third grade vocabulary level.

The Readiness Test, similar to that used in Experiment 3 - Capitalization, was a list of 25 of the most difficult words in the Punctuation Program selected by inspection. Each was used as the keyed response in a multiple choice question in which the stem was a sentence with a word omitted. Two sample items are shown below:

The sewing __________ won't work.

☐ picture ☐ machine ☐ letter ☐ dress

I spend many hours __________ on the violin.

☐ ringing ☐ hiding ☐ tearing ☐ practicing

It was recognized that the test items tap a complex verbal repertoire. However, in the absence of a definitive analysis of the reading behavior prerequisite to success on the program, the test was judged a suitable screening measure.

Criterion Achievement Tests. Two content equivalent tests were constructed to measure pre and post instruction performance. Each test contained 127 items, sampling the 24 content units about equally. The response required was a two-choice discrimination of whether the sentence was correctly punctuated at the point indicated. A standard IBM 805 machined-scorable answer sheet was used to record responses.

The first few items of the test are shown below:

A. Mrs. Jones liked the hat. Then she saw the price$\underset{1}{\underline{.\ \ }}$ Wow$\underset{2}{\underline{,\ \ }}$

B. The Declaration of Independence was signed in$\underset{3}{\underline{,\ \ }}$ July$\underset{4}{\underline{\quad}}$1776.

C. No$\underset{5}{\underline{!\ \ }}$ That isn't Bob's cap.

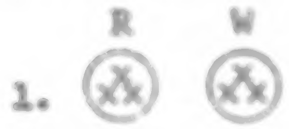
D. Mrs. Ames$\underset{6}{\underline{\quad}}$the fifth grade teacher, reported$\underset{7}{\underline{\quad}}$at the meeting.

E. Dear$\underset{8}{\underline{\quad}}$ Paul$\underset{9}{\underline{:\ \ }}$

Mrs$\underset{10}{\underline{\quad}}$Fry said that$\underset{11}{\underline{\quad}}$both your report and your poem were excellent.$\underset{12}{\underline{"\ \ }}$

Unit Tests. A pretest and a posttest for each unit was constructed, designed to sample the behavioral objective being shaped in the unit. Each test ranged from 6 to 18 items in length. For the most part, the items were two-choice discriminations of correct and incorrect punctuation in single sentence context. However, constructed response items were also included in a few of the tests. All of the unit tests were included in a single booklet of Unit Tests. Pretest keys were included at the back of the test book for pupil scoring.

Review Exercises. A "Review Exercise" was prepared for each unit except the first. Each exercise was designed to sample by successive approximations the behavior involved in the post experiment Criterion Achievement Test. However, units which were two, three, and four units removed from the one being covered were deliberately over-represented in an attempt to equalize the overall "review" coverage of each unit in the program. Each Review Exercise used the same general format as the final Criterion Test. Responses were recorded on a mimeographed answer sheet using the format below for the item responses:



For selected classes the x's in the keyed spaces were printed with the special "red" ink described in Appendix F. Pupils in these classes marked their response with a regular fountain pen containing a very light blue water base ink so that the red dye bled to a reddish-purple for keyed responses. The Review Exercise for each unit was distributed to pupils individually by the teacher.

Design

Four different instructional treaments were investigated:

1. Program + Chemically Treated Review Exercises
2. Program + Review Exercises, Not Chemically Treated
3. Program Only
4. Chemically Treated Review Exercises Only

Each of the four treatments was randomly assigned to a fourth and fifth grade class in a single elementary school. Since the school included five classes at each level, the remaining class was assigned to Treatment 1.

Procedure

All classes were given the Readiness Test the first day of the experiment, Criterion Achievement Test, Form A, the second day, and "How to Use a Programmed Text" the third day.

Each pupil worked on the instructional program at his own pace, responding approximately 30-40 minutes daily. The sequence of procedures for each unit was as follows:

1. Pupil takes the Unit Pretest and scores the test using the key in the back of the Test Book. With one error less he goes to the Unit Posttest. If he has more than one error he responds to the programmed text before taking the Unit Posttest.

2. Upon completion of the Unit Posttest, the test is scored by the teacher. If the pupil has a perfect score, he is given a Review Exercise. If he has any errors, he is required to repeat the programmed instruction and respond to a fresh Posttest. If he makes more than one error on the second attempt at the Posttest, the teacher may use her discretion as to whether he moves on to the Review Exercise or repeats the programmed instruction.

Pupils responding to the pretreated Review Exercies totalled their correct responses and recorded the score at the top of the answer sheet before going on to the next Unit Pretest. Pupils responding to non-treated Review Exercises turned their answer sheets in to the teacher upon completion. These were picked up daily by E for scoring and were returned with correct responses and total scores indicated within 1 to 3 days.

Pupils in Treatment 4 responded to one Review Exercise daily and were given Criterion Achievement Test, Form B, the day following completion of the last exercise. All other pupils were given the Criterion Achievement Test, Form B, the day following their completion of the program.

Results

Table 18 presents the descriptive statistics for the treatment groups at each grade level. Table 19 presents the means on the final

TABLE 18

Descriptive Statistics for Treatment Groups by Grade

	Readiness		Achievement Pretest		Achievement Posttest		Units Responded		Units Repeated	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Grade 4										
1	22.23	2.96	82.25	15.35	90.58	17.07	18.73	3.67	15.31	4.22
2	22.38	2.68	82.72	15.58	96.00	16.68	16.34	4.55	12.69	5.83
3	23.00	1.60	89.33	13.30	96.33	13.11	15.50	3.21	11.00	3.25
4	20.88	4.45	79.56	14.87	80.72	16.57				
Grade 5										
1	23.23	3.62	89.64	17.30	99.68	19.01	11.55	4.89	7.30	4.41
2	23.24	3.05	89.88	15.30	98.41	22.21	12.12	5.30	7.71	4.61
3	23.43	1.89	94.48	14.99	105.95	16.38	15.38	3.63	9.14	6.21
4	24.04	1.17	96.56	14.59	92.84	16.14				

TABLE 19

Adjusted Mean Criterion Test Scores by Grade

	Treatment				
Grade	1	2	3	4	F
4	91.45	96.36	92.00	83.74	1.50
5	100.58	99.29	102.93	89.45	.40

Criterion Achievement Test adjusted for initial differences in performance on the Readiness Test and on the pre-experiment Criterion Achievement Test. Although the overall difference in performance among the groups is not statistically significant at either grade level, the performance of pupils in the treatment responding only to Review Sheets is significatnly lower ($P<.05$) than any of the other treatment groups. Each of the programmed groups achieved a respectable relative learning increment, as evidenced by both the final Criterion Achievement Test and by Review Sheet performance. However, the instruction again fell short in terms of absolute achievement of the instructional objective.

Evaluation of Results for Final Revision

Aside from the substantive results the experiment yielded important procedural findings. The classroom logistics proved overwhelming. As indicated in the descriptive statistics, there was a considerable degree of bypassing. Teachers became completely bogged down in scoring the Unit Posttests, so that delays of five to ten minutes for a child were not uncommon. Although the directions concerning the bypassing contingencies and overall sequencing were specifically spelled out, pupils had just enough difficulty following them and finding their place at the next point in the program to cause a teacher considerable difficulty. Actually, the situation was no more uncontrolled or complicated in this experiment than in previous preliminary experiments. However, up until this time we had rationalized or otherwise excused the situation. We had, along with our colleagues, accepted without question the "strength" of self instruction in meeting individual differences through self pacing. We came to realize only very gradually that "things are not as simple as they first appear" with respect to "each pupil proceeding at this own rate" in the standard classroom situation.

A second "obvious" finding was that the criterion of no errors on the Unit Posttests was unrealistic. Too many pupils simply did not achieve this criterion. The recycling through programmed units was difficult to manage and resulted in uncontrolled variability from teacher to teacher. Altogether the contingencies, although simple for a single pupil in a controlled laboratory situation, proved much too complex to be manageable in a natural classroom situation.

The chemical feedback showed considerable promise, even though there were a few bugs. The color reaction worked well. However, many pupils exercised much greater ingenuity in identifying non-programmed discriminative stimuli than in yielding stimulus control of their behavior to the program. For example, in preparing the answer sheets it was necessary to print the keyed and non-keyed answer spaces on separate runs of the mimeograph machine. While an "uneducated" person would be extremely unlikely to detect any differences in registration, some pupils could be counted upon to shape up a very precise discrimination. These irrelevant discriminations proved extremely resistant to extinction. When coupled with superstitious behavior such as position response sets which were adventitiously reinforced on a variable schedule, the "irrelevant" competition with item content for stimulus control was intense. For many pupils, the program placed second. Again it was clear that the overall complexity of the logistics made it impossible for the teacher to provide the kind of backup support of the reinforcement contingencies necessary to support the desired stimulus control.

CHAPTER III

REVISED BEHAVIORAL ANALYSES AND EXPERIMENTAL VARIATIONS

Rationale for the Revised Analyses

Together, the preliminary experiments pointed to the need for a much finer grain analysis of the component response classes making up the overall instructional objectives of the three areas of interest in the project. Although our efforts from the earliest stages of constructing the instructional programs constituted a series of successive approximations with respect to refinement of the instructional objective, it became obvious that a more systematic approach was required.

It was now readily apparent that "steering the pupil through a carefully arranged sequence of stimuli" was insufficient to insure acquisition of behavior. To this date our instruction had focused largely on presentation of positive (S+) discriminative content; on "what to do." Negative (S-) discriminative stimuli (when not to make a response) had been underemphasized. The S+ approach is perfectly adequate if the instructional objective is simply low error rate in the program. However, it fails miserably if the objective is to bring the behavior under the control of both S+ and S- stimulus classes. Describing our behavior in common psychological terminology, we had assumed that at least a modest degree of generalization or transfer of training would occur and had instead identified faulty generalization and retroactive interference. Unfortunately, however, such a postdictive "description" was of little value in pointing to a behavioral route for improving the instructional effectiveness of the programs.

Hively's (1963) item form concept did provide the necessary cues for the kind of analysis we desired. As noted in Chapter I, an item form provides an operational definition of a homogeneous response class. This definition concurrently provides a blueprint for an instructional component and for a test to measure the acquisition of this component.

We found in working with the item form concept that it could be applied at various levels of precision. The illustrative application which Hively (1963) presents yields a very fine grain molecular analysis of a subject matter domain. Our requirements, on the other hand, were a good deal more molar in nature. Our purpose called for a road map rather than a topographical map. Although the two kinds of maps are compatible, the topographical map becomes cumbersome and inefficient if the objective is simply to get from one place to another as rapidly as possible.

We, therefore, modified Hively's format, using the following headings:

> Unit Objective - Behavioral specification of the behavioral response class for a given component of the program.
>
> Instructional Cues - Discriminative verbal stimuli which can be used to mediate the behavior of interest. These correspond to a combination of Hively's "mediating behavior" and "notes to the student." However, they are written using vocabulary at the pupil's rather than the instructor's level so that they can be used without great modification in the instructional sequence.
>
> Eliciting Cues - These correspond to Hively's "instructions." They present the exact words used to elicit a response from the pupil. In psychometric terminology they are analogous to "stems" for a set of test questions.
>
> Limits - Specification of the population boundaries encompassing all of the members of the component response class of interest. Usually it is necessary to specify both S+ and S- stimuli to clarify the boundary limits.

Tables 20 to 22, which appear at the end of this chapter, present the item forms prepared for each of the three areas. The item forms mediated only minor changes in the Unit Pre- and Posttests. However, they suggested radical and extensive revision of many of the programmed instructional units. In addition to revisions within a unit, reflection on the entire collection of item forms for a subject matter area suggested several possibilites for the consolidation of units and the rearrangement of unit sequencing for increased programing efficiency.

Analysis of Classroom Controlling Contingencies

The preliminary experiments also pointed to the need for a much more systematic consideration of the specific controlling contingencies in a classroom, in addition to those in the program per se. Our initial efforts had assumed that the program would automatically be the major determinant of the pupil's behavior. We found this to be an oversimplified view. The results of the preliminary experiments made it painfully obvious that what we had previously regarded as pedestrian and unimportant aspects of the classroom were at least minimally powerful to compete vigorously with the program for stimulus control, and were maximally powerful to reduce the program to feeble S- status.

We realized that we lacked both the knowledge and the authority to alter these external conditions in any significant fashion within the scope of the present research. However, our post-experiment discussion with the participating teachers finally convinced us that at least for the purposes of the experiment, it would significantly simplify the teacher's task if individual pacing were on a daily rather than on a full-experiment basis. If each child were to start at the same point each day, the logistics problem would be reduced and the teacher would have his customary feeling that things were under control and that he knew what was going on. Since the teachers were making no systematic efforts to further the instruction of pupils who finished the total program several days, or weeks, ahead of the other pupils, we could see no harm and several benefits in accepting the teachers' suggestion. Therefore, the final experiments were each paced on a daily basis.

Within the limits available to us, it appeared that two variables warranted immediate experimental variation at this point. First, a systematic investigation of the effectiveness of the Unit Tests as a basis for bypassing was required. Secondly, the role of the Review Exercises and the reinforcing contingencies surrounding their use deserved further exploration. The use of the chemical treatment to provide knowledge of results appeared promising and worthy of a more systematic test. The final experiments, therefore, were designed to investigate the function of bypassing and maintenance.

Note

The item forms which follow are an integral part of the report. Although they are required reading for full "understanding and apprection" of the remainder of the report, readers not desirous of full understanding and appreciaton will find the next chapter begins on page 102.

TABLE 20

Capitalization Unit 1

Unit Objective

Discriminative use of terminal punctuation of a sentence as S+ for capitalization.

Instructional Cues

1. The first word in a sentence is always capitalized.
2. Do not begin a line with a capital letter unless it is a new sentence.
3. Use a capital letter to begin the word after a period, question mark, or exclamation point.
4. Use a small letter to begin the word after a comma.
5. Use a small letter to begin the word after a period following an abbreviation in the middle of a sentence.

Eliciting Cues

1. Should this word begin with a capital letter or a small letter?
2. Which word in a sentence is always capitalized?
3. The word after a (terminal punctuation) begins with a _______________ letter.
4. Mark the words that should be capitalized.

Limits

S+

1. .
   ?
   !
2. Abbreviation & new sentence
3. Period
4. Exclamation point
5. Question mark
6. First word of single sentence
7. First word of sentence in a medial position

S-

1. Abbreviated words not at the end of a sentence
2. , and ;
3. Comma
4. New lines not a new sentence
5. Words in the sentence, not proper nouns
6. Semicolon

Capitalization Unit 2

Unit Objective

Discriminative tact and use of the letter I and its contractions as S+ for capitalization.

Instructional Cues

1. The word I is always capitalized.
2. The letter I in contractions (examples) is always capitalized.
3. Even if the word I or its contractions comes in the middle of the sentence, it is written with a capital letter.

Eliciting Cues

1. Which word is a capital letter?
2. Which word is always capitalized?
3. With what kind of a letter do you write the word I, or its contractions?

Limits

S+	S-
I, I'm, I'll, I've, I'd	1. The word "a" 2. Other pronouns such as: you, me, we, us, my, your, mine, he, his, theirs, our, they, them, etc. 3. Small words starting with "i" such as: it, is, in, ice, it, into

Capitalization Unit 3

Unit Objective

Discriminative tact and use of proper name and initials as S+ for capitalization.

Instructional Cues

1. Always capitalize a person's name.
2. Both the first name and last name should always begin with a capital.
3. Do not capitalize words which tell what kind of a person.
4. Capitalize a word used in place of person's name.
5. The first letter of a person's name used by itself is called an initial.
6. Use a capital letter to write an initial.
7. An initial (or initials) used in place of a person's name is always capitalized, and a period placed after it.
8. An initial can be used for a person's first name, middle name, and sometimes for the first, middle, and last names.

Eliciting Cues

1. Which word (or words) is the name of a person?
2. Which words in this sentence should begin with a capital letter?
3. Capitalize correctly the following:
4. Which word (or words) is used in place of a person's name?
5. Which is an initial? How can you tell?
6. Which is the correct way to write a person's initials?
7. What is the rule for writing the initials for a person's name?

Limits

S+	S-
1. Variety of first names used singularly	Common nouns related to persons and pronouns such as: you, me, him, she, her, brother, his, sister, aunt, uncle, they, we, me, driver, salesman, doctor, hunter, teacher, janitor, neighbor, principal, and other short words
2. First, middle, and last names used together	
3. Words used as a part of a person's name, such as: Uncle, Aunt	
4. First name, middle initial, last name.	
5. First initial, middle initial, last name.	
6. First initial and last name	
7. Three initials	

Capitalization Unit 4

Unit Objective

Discriminative use of names of days and months as S+ for capitalization.

Instructional Cues

1. The seven days of the week and twelve months of the year are names.
2. The names of the days and months are always capitalized.
3. A word which tells the kind of day or kind of month is never capitalized.
4. Abbreviations of names of days and months are always capitalized.

Eliciting Cues

1. Tell whether these words are names or kinds.
2. Which are names of days of the week?
3. Which are names of months?
4. Which should be capitalized?

Limits

S+	S-
1. Days of week and months of year in isolation and in various positions in a sentence	Common nouns such as: yesterday, week, month, year, tomorrow, semester, night, dawn, morning, afternoon, etc.
2. Abbreviations of days of the week and months of the year	

Capitalization Unit 5

Unit Objective

Discriminative tact and use of names of holidays as S+ for capitalization.

Instructional Cues

1. The name of a holiday is like the name of a person.
2. The names of holidays sometimes include more than one word.
3. Always capitalize every word in the name of a holiday.
4. A word that tells what kind of a day is never capitalized.
5. Holidays do not have to be vacations from school or work.

Eliciting Cues

1. Tell whether these words are names of kinds:
2. Which are names of holidays?
3. Which of the following holidays are vacations from school?
4. Which should be capitalized?

Limits

S+	S-
Names of 18 commonly recognized holidays in isolation and in context	1. Common nouns related to holidays such as birthday, holiday, celebration, party, first day of school, last day of school, recess, trip 2. Phrases such as day off, every day, some day

Capitalization Unit 6

Unit Objective

Tact of names of organizations. Discriminative tact of important and unimportant words in the name. Use of the tacts as S+ for capitalization.

Instructional Cues

1. A group of people can be called an organization.
2. Always capitalize the important words in the name of an organization.
3. A word or phrase that tells what kind of an organization is never capitalized.
4. Words in the name which are abbreviated should be capitalized.

Eliciting Cues

1. Which are groups of people?
2. Which are names of groups of people?
3. Tell whether these are names or kinds of organizations:
4. Which should be capitalized?
5. What words in the name of an organization should not be capitalized?

Limits

	S+	S-
1.	Single and multiple word names such as: Congress, Senate, San Francisco Giants, United Nations, American Legion, House of Representatives, Sears, Roebuck and Company, Associated Press	Common nouns and phrases such as: a state legislature, a political party, ball team, business, third grade girls, unions, corporation, company
2.	Combinations of the above using abbreviation of appropriate words	
3.	Sampling of above includes names with such unimportant words as and, the, of, etc.	

Capitalization Unit 7

Unit Objective

Discriminative tact and use of the name of (or part of the name) of a relative as S+ for capitalization.

Instructional Cues

1. If a word used as the name of a relative is immediately before a person's name (or part of his name), the word is always capitalized.
2. If a relationship word is plural, it tells the kind of person and is not capitalized.
3. My brother has the ball.

   To decide whether the word is a name or kind, ask, "If I called the person by his first, last, or full name, what would I say?"

   Answer: "John has the ball."

   Are any words left out in one of the sentences?

   If the answer is "yes," the word is a kind, and it is not capitalized.

   If the answer is "no," the word is a name, and it is capitalized.

Eliciting Cues

1. Does the word tell what kind of relative, or is it used in place of the name, or is it used with a name?
2. Which of these sentences is correct?
3. Which word should be capitalized?
4. What is the rule for capitalizing words used in place of a relative's name?

Limits

S+	S-
1. The following used in isolation or in context, in all upper case or all lower case: Father, Mother, Sister, Brother, Grandmother, Grandfather, Aunt, Uncle, Niece, Nephew, Mom, Pop, Dad	1. All of the S+ list preceded by such words as: my, her, our, your, all; adjectives; possessive nouns
2. The above list used also in combination with proper names	2. Common nouns: friend, neighbor, pal, relative, student, pupil, teacher, etc.

Capitalization Unit 8

Unit Objective

Discriminative tact and use of person's title as S+ for capitalization.

Instructional Cues

1. Capitalize words or abbreviations of words used as titles of people.
2. Do not capitalize word used as title if it tells what kind of person.
3. Capitalize words used as titles when they are used instead of a name.
4. Capitalize words used as titles when they are used with a name.

Eliciting Cues

1. Does this word tell what kind, or is it a title for a person?
2. Is this a title with a name? A title used in place of a person's name? A word that tells what kind of person?
3. What is the rule for capitalizing words and abbreviations used as titles?

Limits

S+	S-
The following used in isolation and in context, the full word and abbreviations where appropriate, and with a name and in place of a name: Mister, Mrs., Miss., President, Senator, Judge, Hon., Reverend, Dr., Lord, Lady, King, Queen, etc.	The words in S+ list used as adjectives, verbs, and common nouns

Capitalization Unit 9

Unit Objective

Discriminative tact and use of names of places as S+ for capitalization.

Instructional Cues

1. Capitalize every word in the name of a place.
2. Words describing what kind of place are not capitalized.
3. Abbreviations of names of places are capitalized.
4. All the words in the name of a street are capitalized.

Eliciting Cues

1. Which is a name?
2. Do you capitalize
   names of places?
   kinds of places?
   abbreviations of names?
   all the words in the name of a street?
3. Which words should be capitalized?

Limits

S+

Specific names used in combination with the following -- in isolation or in context:
- Business names
- Addresses
  - street, avenue, highway, boulevard, parkway, drive, place, alley, trail, roads
- Geographical
  - town, city, village, county, country, state, continent

S-

1. Bodies of water - kinds
   rivers, streams, creeks, lakes, oceans
2. Public (civic) locations
   schools, parks, museums, municipal buildings
3. Any of the nouns from the S+ list preceded by an adjective, verb, or pronoun which serves to describe a class rather than name a specific place.

Capitalization Unit 10

Unit Objective

Discriminative tact and use of names of parts of our country as S+ for capitalization.

Instructional Cues

1. Capitalize words which are names of parts of our country.
2. Words used as directions are not capitalized.
3. Words used to names parts of a city or state are not capitalized.

Eliciting Cues

1. Is this word used as a name of a part of our country?
2. Is this word used as a direction?
3. Is this word used as a name or a part of a city or state?
4. Why is this word capitalized?
5. Why is this word not capitalized?
6. Which should be capitalized?

Limits

S+	S-
Name of part of country: the North, the South, the East, the West, the Northeast, the Northwest, the Southeast, the Southwest, used by themselves in isolation and in context.	1. Direction - such as: row far east, he sailed south, east on Oak Street 2. Part of a city or state ____ern ____ward ____side ____part

Capitalization Unit 11

Unit Objective

Discriminative tact of important and unimportant words in the name. Use of the tacts as S+ for capitalization.

Instructional Cues

1. A title is the name of a publication.
2. Things like books, stories, poems, pieces of music, newspapers, and magazines are called publications.
3. Always capitalize the important words in the title of a publication.
4. Words that tell what kind of publication are never capitalized.
5. Some words in a title are not very important. Do not capitalize this kind of word unless it is the first word in the title.

Eliciting Cues

1. Tell whether these words are titles or kinds of publication.
2. What is the capitalization rule for title? for kinds?
3. Which words in this title should you capitalize?
4. Which words are unimportant?
5. Which words do you capitalize in this sentence?

Limits

S+	S-
1. Each category sampled in following manner: Books The Adventures of Tom Sawyer, Jack and the Beanstalk, Fun with Dick and Jane, A Day to Remember Stories Poems Pieces of music Newspapers Magazines	1. Kinds such as: newspaper, story, good book, music book, library book, mystery story, evening newspaper, poems, march, weekly magazine, piano pieces
2. Important small words: is, are, why, now, then, three, will, have, etc.	2. Unimportant small words: a, an, from, to, on, for, up, the, and, in, of, with, etc.
3. Above presented in isolation and in a variety of contexts	3. Above presented in isolation and in a variety of contexts

Capitalization Unit 12

Unit Objective

Discriminative tact and use of names of nationalities used alone or in an adjectival sense as S+ for capitalization.

Instructional Cues

1. A nationality names a country someone or something is from.
2. Capitalize the nationality.
3. Never capitalize the kind of person or thing referred to.

Eliciting Cues

1. Which word is a nationality? Not a nationality?
2. What is the capitalization rule for nationalities?
3. Which words would be capitalized?

Limits

S+

English
French
American
Swedish
Chinese
Mexican
German
Spanish
Eskimo
Japanese
Canadian
Italian
Greek

S-

Kinds of people:
- ladies
- actress
- dentists
- doctors
- people
- grocer
- authors
- children
- etc.

Things:
- spice
- restuarant
- chocolate cake
- apple pie
- food
- cooking
- meeting
- holiday

Capitalization Unit 13

Unit Objective

Discriminative tact and use of the first word of a quotation as S+ for capitalization.

Instructional Cues

1. Look at the words that someone spoke. Are they his exact words?
   a. If your answer is "yes," the words are a quotation.
   b. If your answer is "no," the words are not a quotation.
   c. If you're in doubt, look at the word after "said" (or after the word which means "said"):

      If it is "that," the words usually are not a quotation.

      If it is not "that" but you can put in "that" after "said" (or the word that means "said") without changing the meaning, the words usually are not a quotation.

      If it is not "that" and if you can't put in "that" after "said," (or the word that means "said") the words usually are a quotation.
2. Ask yourself, "Are the words a quotation?"
   a. If your answer is "yes," always capitalize the first word.
   b. If your answer is "no," don't capitalize the first word unless it is a word that needs to be capitalized for one of the reasons you've already learned.

Eliciting Cues

1. Tell whether these are quotations.
2. Tell whether or not this word is the first word of a quotation.
3. How many quotations in this sentence?
4. Which sentence has a quotation? Which sentence does not have a quotation?

Limits

S+	S-
1. Exact words, one phrase, punctuated and not punctuated	1. Indirect quotes, punctuated and not punctuated
2. Broken quote, one sentence	2. Words/phrases used to cue indirect quote: said that, told us, told me, replied that, etc.
3. Broken quote, two sentences	
4. Words used to cue exact words: asked, said, replied, answered, spoke	

TABLE 21

Fractions Unit 1

Unit Objective

Discriminative tact of fractions and whole numbers presented semantically, figurally, and symbolically.

Instructional Cues

1. This is a whole number (example).
2. This is a fraction (example).

Eliciting Cues

1. Which is a whole number?
2. Which is a fraction?
3. What is this? (3297)
4. What is this? (eleven sixteenths)
5. Is there a fraction at ________?

Limits

S+	S-
1. Whole numbers of 4 digits or less 2. Fractions with numerators of 2 digits or less	Mixed numbers a) fractions b) decimals

Fractions Unit 2

Unit Objective

Tact of numerator as the top number in a fraction.

Instructional Cues

The top number is the numerator.

Eliciting Cues

1. Is this a numerator?
2. Which is the numerator?
3. What is this? → $\left(\frac{5}{12}\right)$
4. What is this? → $\left(\frac{12}{5}\right)$

Limits

S+	S-
Top number in a fraction 1 or 2 digits a) symbolically expressed b) semantically expressed	1. Bottom numbers in a fraction 2. Whole numbers 3. Mixed numbers 4. Decimal fractions 5. Part of a numerator (e.g., the 4 in $\frac{14}{15}$)

Fractions Unit 3

Unit Objective

Tact of denominator as the bottom number of a fraction.

Instructional Cues

The bottom number is the denominator.

Eliciting Cues

1. Is this a denominator?
2. Which is the denominator?
3. What is this? → ($\frac{5}{12}$)
4. What is this? → ($\frac{12}{5}$)

Limits

S+	S-
Bottom number in a fraction 1 or 2 digits a) symbolically expressed b) semantically expressed	1. Top number in a fraction 2. Whole numbers 3. Mixed numbers 4. Decimal fractions 5. Part of a denominator (e.g., the 5 in $\frac{14}{15}$)

Fractions Unit 4

Unit Objective

Discrimination of numerator and denominator.

Instructional Cues

The top number is the numerator and the bottom number is the denominator.

Eliciting Cues

1. Is this a numerator? a denominator?
2. Which is the numerator? the denominator?
3. What is this? and this?

Limits

1 or 2 digit numerators and denominators

S+	S-
Numerators and denominators in common fractions	1. Whole numbers a) in mixed numbers b) in mixed decimal fractions c) alone 2. Decimals 3. Part of a numerator or denominator

Fractions Unit 5

Unit Objective

Tact of proper fraction

Instructional Cues

The numerator of a proper fraction is always smaller than the denominator.

Eliciting Cues

1. Is this a proper fraction? Which is a proper fraction?
2. What is this? (1/3) What is this? (three fourths)
3. If you put a 3 in the blank, would you have a proper fraction? $\left(\frac{?}{3}\right)$
4. Is there a proper fraction at ________?

Limits

S+	S-
Fraction in which numerator is smaller than denominator	1. Fractions in which numerator is as large as or larger than denominator 2. Mixed numbers 3. Whole numbers

Fractions Unit 6

Unit Objective

Tact of improper fraction

Instructional Cues

The numerator of an improper fraction is as large as or larger than the denominator.

Eliciting Cues

1. Is this an improper fraction? Which is an improper fraction?
2. What is this? (3/2) What is this? (three halves)
3. If you put a 12 in a blank, would you have an improper fraction? $\left(\frac{\_\_\_}{9}\right)$
4. Is there an improper fraction at _______?

Limits

S+	S-
1. Fraction in which numerator is same size as denominator 2. Fraction in which numerator is larger than denominator	1. Fractions in which numerator is smaller than denominator 2. Mixed numbers 3. Whole numbers

Fractions Unit 7

Unit Objective

Discrimination of proper and improper fractions.

Instructional Cues

The numerator of a proper fraction is smaller than the denominator, but the numerator of an improper fraction is the same size as or larger than the denominator.

Eliciting Cues

1. Is this a proper fraction, an improper fraction, or neither one?
2. Which number would you put in the blank to make a proper fraction: $\frac{(\_\_)}{6}$ 5, 6, or 7?
3. Which number would you put in the blank to make an improper fraction: $\frac{(\_\_)}{6}$ 4, 5, or 6 ?

Limits

S+	S-
Proper and improper fractions	1. Whole numbers 2. Mixed numbers

Fractions Unit 8

Unit Objective

Tact of mixed numbers.

Instructional Cues

A mixed number is a whole number and a fraction.

Eliciting Cues

1. Is this a mixed number?
2. Which is the mixed number?
3. What is this? (3 2/3)
4. What is this? (one and one half)
5. Is there a mixed number at ____________?
6. Is this a (proper fraction, improper fraction, whole number, or mixed number)?

Limits

1-, 2-, or 3-digit whole numbers, numerators, and denominators

S+	S-
Any mixed number	1. Proper fraction 2. Improper fraction 3. Whole number

Fractions Unit 9

Unit Objective

Addition of like fractions whose sum requires no reducing and is less than 1.
Tact of functions of numerator and denominator.

Instructional Cues

1. Add the numerators but don't add the denominators.
2. The numerator tells how many.
3. The denominator tells what kind.

Eliciting Cues

1. Does this number tell how many? $\left(\rightarrow \frac{3}{5}\right)$
2. Does this number tell what kind? $\left(\rightarrow \frac{3}{5}\right)$
3. Which number tells how many? What kind?
4. Is there a number that tells what kind, how many, at _______?
5. Which numbers do you add? Which numbers do you not add?
6. Terms of the problem presented vertically.
7. Terms of the problem presented horizontally.

Limits

1. Addends whose denominators are less than 10.
2. Sums less than 1.
3. Sums requiring no reducing.

Fractions Unit 10

Unit Objectives

Subtraction of like fractions whose remainder requires no reducing and is less than 1.

Instructional Cues

Subtract the smaller numerator from the larger numerator and copy the denominator.

Eliciting Cues

1. Which number do you subtract?
2. Which number do you copy?
3. Terms of the problem presented vertically.
4. Terms of the problem presented horizontally.

Limits

1. Subtrahends and minuends whose denominators are less than 10.
2. Remainders less than 1.
3. Remainders requiring no reducing.

Fractions Unit 11

Unit Objective

Addition of a whole number and a mixed number.

Instructional Cues

Copy the fraction; then add the whole numbers.

Eliciting Cues

1. Sum shown in figures (i.e., illustrations). What is corresponding number?
2. Addition problems, without illustrations, with plus sign.

Limits

Whole numbers in both addends less than 10

Fractions Unit 12

Unit Objective

Subtraction of a whole number from a mixed number.

Instructional Cues

1. When terms of subtraction problem presented vertically with subtrahend at least one less than minuend,
   a. subtract nothing in the fractions' column. (Copy the fraction in the minuend.)
   b. subtract the whole number in the subtrahend from the whole number in the minuend.
2. When whole numbers in terms of problem are equal and remainder is a simple fraction,
   a. copy the fraction in the minuend.
   b. do not write a zero in the remainder. (The complete answer is a simple fraction.)

Eliciting Cues

Subtraction problems with minus sign

Limits

Whole numbers in both terms of the subtraction problem are less than 10.

Fractions Unit 13

Unit Objective

Subtraction of equal minuends and subtrahends

Instructional Cues

1. When the minuend and subtrahend are the same, the answer is 0.
2. Do not use 0 as a numerator (Wrong: $\frac{0}{2}$; Correct: 0).

Eliciting Cues

1. Problems presented in vertical and in horizontal form with minus sign.
2. Wrong: $\frac{0}{5}$ Right: (0)

Limits

Whole numbers in both minuend and subtrahend are less than 10.

Fractions Unit 14

Unit Objective

Tact of the word terms as applicable to the numerator and denominator.
Change fractions from lower to higher terms.

Instructional Cues

1. The terms of a fraction are the numerator and denominator.
2. If the two terms of a fraction are identical, the fraction = 1.
3. When you multiply a fraction by 1, you do not change its value.
4. When you multiply both terms of a fraction by the same number, it is the same as multiplying by 1.
5. To change a fraction to higher terms, multiply both terms by the same number.
6. To change a fraction to higher terms, first divide the denominator of the new fraction by the denominator of the original; then multiply both terms by this quotient.

Eliciting Cues

1. Is this a term? $\left(\frac{\rightarrow 1}{2}\right)$
2. Is this a term? $\left(\frac{1}{\rightarrow 2}\right)$
3. Are both the numerator and denominator terms?
4. How many terms does every fraction have?
5. What name is given to the numerator and denominator?
6. What name is given to these two numbers? $\frac{1}{2}$
7. By what number can you multiply a fraction without changeing its value?
8. When you multiply both terms of a fraction by the same number, you are multiplying it by__________.
9. You (do not) change the value of a fraction when you multiply both terms by the ______ ________.
10. Change $\frac{1}{2}$ to fourths.
11. $3/4 = \frac{?}{12}$
12. How many 1/6's are there in 2/3?
13. What fraction is the same size as 2/5?

Limits

S+	S-
1. Fractions with 1-or 2-digit terms	1. Whole numbers
2. Both terms of a fraction multiplied by the same one-digit constant.	2. Decimals
	3. The whole number in a mixed number

Fractions Unit 15

Unit Objective

Discrimination of magnitude of fractions

Instructional Cues

1. To compare the size of two fractions, change the one having the smaller denominator to higher terms.
2. To compare the size of two fractions, they must have the same denominators.

Eliciting Cues

1. Which fraction has the smallest number in the denominator?
2. By what do you multiply the smaller denominator to make it equal the larger denominator?
3. By what do you multiply both terms of fraction x to compare it with fraction y?
4. Which is the smaller of these two fraction?
5. Which is the larger of these two fractions?
6. Write the fraction under the correct word:

$\frac{1}{2}$ $\frac{1}{8}$ $\frac{1}{4}$ Smallest Next larger Largest All the same

Limits

Pairs or groups of fractions having a denominator not larger than 24, and which can be factored by 2, 3, or 5, not more than three fractions in a group.

Fractions Unit 16

Unit Objective

Change whole numbers to improper fractions and tact the procedure.

Instructional Cues

To change a whole number to a fraction, multiply the whole number x the denominator of the improper fraction.

Eliciting Cues

1. What is the whole number?
2. What is the denominator of the fraction to which you're changing the whole number?
3. What process do you use?
4. What are the two numbers you multiply? Do it.
5. Where do you write the product? Do it.
6. Over what number do you write the product? Do it.
7. Change this whole number to a fraction. (Example: $3 = \frac{?}{6}$).

Limits

Both the whole number and the denominator are less than 10.

Fractions Unit 17

Unit Objective

Change mixed numbers to improper fractions and tact the procedure.

Instructional Cues

To change a mixed number to an improper fraction, multiply the denominator by the whole number, add the numerator to the product, and write this sum over the denominator.

Eliciting Cues

1. What is the whole number?
2. What is the denominator?
3. What process do you use? Do it.
4. What is the numerator?
5. What do you do with the answer and the numerator? Do it?
6. Where do you write this answer? Do it.
7. Over what number do you write the product? Do it.
8. Change this mixed number to an improper fraction. (Example: $3\frac{1}{3} = \frac{?}{3}$)

Limits

1. Whole number is less than 10.
2. Denominators include 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, and 16.
3. When denominator $>$10, whole number $<$3

Fractions Unit 18

Unit Objective

Subtraction of like fractions with decomposition
Decomposition of the minuend of a subtraction problem when the minuend is a mixed number.
Tact the decomposition procedure.

Instructional Cues

If the fraction in the minuend is smaller than the fraction in the subtrahend, change the minuend to a mixed number and then subtract.

Eliciting Cues

1. Can you subtract the bottom fraction from the top?
2. If not, change the mixed number to an _________. Do it.
3. In which problem must you change the top number to an improper fraction?
4. Do you need to change the top number to an improper fraction? If so, do it and then subtract.

Limits

1. Whole number in the minuend is 1.
2. Denominators $<$11
3. Denominators are common.

Fractions Unit 19

Unit Objective

Change improper fractions to whole numbers and tact the procedure.

Instructional Cues

To change an improper fraction to a whole number, divide the numerator by the denominator.

Eliciting Cues

1. Are 4 halves (represented in illustrations)the same as 2 (represented in figure illustrations)?
2. Are 4/2 and 2 the same?
3. Can a whole number, like 2, be a proper fraction? improper fraction?
4. Do you multiply or divide to change $\frac{4}{2}$ to 2?
5. What do you divide to change an improper fraction to a whole number? Do it with this: $\frac{9}{3}$

Limits

1. Denominator$<$11
2. Whole number$<$10

Fractions Unit 20

Unit Objective

Addition of simple fractions whose sum is greater than 1.

Instructional Cues

If the answer is an improper fraction, change it to a whole number.

Eliciting Cues

1. Is the answer a proper fraction?
2. If not, what do you do? Do it.

Limits

1. Two- or three-addend problems.
2. Answers are either 1 or 2.
3. Denominators are 2,3,4,5,6,7,8,9,10,12, or 16.
4. Denominators are common.

Fractions Unit 21

Unit Objective

Reduce fractions to lowest terms and tact the procedure.

Instructional Cues

1. The reducer is the number by which both terms are divided to reduce a fraction to lowest terms.
2. To find a reducer, first try dividing both terms by the numerator.
3. If this cannot be done without a remainder, divide the numerator by 2 and try the quotient as a reducer.
4. If this number is not the reducer, repeat the process, dividing the numerator by 3, by 4, etc., until the reducer is discovered.

Eliciting Cues

1. Which fraction has the lowest-terms? $\left(\frac{2}{6}\ \frac{1}{3}\ \frac{3}{9}\right)$
2. Does 3 go into both terms without a remainder? $\left(\frac{6}{9}\right)$
3. Does the numerator go into both terms without a remainder? If so, write the fraction (lowest terms).
4. If not, divide the numerator by 2. Does this answer go into both terms without remainder? If so, write the fraction (lowest terms).
5. If not, divide the numerator by 3, etc.
6. Circle the fractions that can be reduced.

Limits

1. Reducer, if not the numerator, is <6.
2. Fractions to be reduced have a denominator <26.

Fractions Unit 22

Unit Objective

Change an improper fraction to a mixed number and tact the procedure.

Instructional Cues

1. Divide the numerator by the denominator.
2. Write the quotient as a whole number and the remainder over the denominator.

Eliciting Cues

1. Which of these two can be changed to a whole number? a mixed number? $\frac{17}{3}$ $\frac{18}{3}$
2. If you divide the numerator of an improper fraction by the denominator and the answer comes out even, the improper fraction equals (a whole, a mixed) number.
3. 5/3 can be changed to (a whole, a mixed) number.
4. If you change 7/3 to a mixed number, the denominator of the fraction in the mixed number will be______.
5. Change 7/4 to a mixed number.

Limits

1. Numerators < 30
2. Denominators < 11
3. Quotients < 10

Fractions Unit 23

Unit Objective

Addition and subtraction of fractions involving reducing and changing to whole or mixed numbers.

Instructional Cues

None

Eliciting Cues

Problems with terms presented vertically and horizontally.

Limits

1. Addends, minuends, and subtrahends < 10.
2. Denominators < 17.

TABLE 22

Punctuation Unit 1

__Unit Objective__

Discriminative use of period, question mark, and exclamation point as terminal punctuation for declarative, interrogative, and exclamatory sentences.

__Limits__

Simple, compound, complex sentences; indirect questions; compound interrogative sentences composed of a declarative independent clause followed by an interrogative independent clause.

No capitalization cues provided. Does __not__ include incomplete sentences.

Sub-objective 1

Discriminative tact of period and question mark symbols.

__Instructional Cues__

1. This is a period (symbol shown).
2. This is a question mark (symbol shown).

__Eliciting Cues__

1. Which is a period?
2. Which is a question mark?
3. What is this: (.)?
4. What is this: (?)?
5. Is there a period at _____?

__Limits__

S+	S-
1. period .	1. question mark, comma, exclamation point ? , !
2. question mark ?	2. period, comma, exclamation point . , !

Sub-objective 2

Discriminative tact of declarative and interrogative sentence.

Instructional Cues

1. (Declarative sentence) This sentence tell you something. It is a telling sentence.
2. (Interrogative sentence) This sentence is not a telling sentence. It is a question.

Eliciting Cues

1. Is this a telling sentence?
2. Is this a tulling sentence or a question?

Limits

Simple, compound, complex sentences; indirect questions.

Sub-objective 3

Discriminative use of period as terminal punctuation of declarative sentence and question mark as terminal punctuation of interrogative sentence.

Instructional Cues

Rule 1: Use a period at the end of a telling sentence.
Rule 2: Use a question mark at the end of a question.

Eliciting Cues

Show whether the sentence should end with a period or a question mark.

Limits

Simple, compound, complex sentences; indirect questions; compound interrogative sentences composed of declarative independent clause followed by an interrogative independent clause.

Sub-objective 4

Discriminative tact of exclamation point symbol.

Instructional Cues

This is an exclamation point (sample shown).

Eliciting Cues

1. Which is an exclamation point?
2. What is this: (!)?
3. Is there an exclamation point at ____?

Limits

S+	S-
Exclamation point !	Question mark, comma, period, apostrophe ? , . '

Sub-objective 5

Discriminative use of exclamation point as terminal punctuation of exclamatory sentences.

Instructional Cues

Rule 3: Use an exclamation point at the end of a sentence which shows excitement or surprise.

Eliciting Cues

1. Which sentence shows excitement?
2. Show which mark should end each sentence.
3. (ex) What would you use to show excitement? make this a question? tell someone this without excitement?

Limits

1. Declarative, interrogative, and imperative sentences.
2. Simple, compound, complex sentences; indirect quotations; compound interrogative sentences composed of declarative independent clause followed by an interrogative independent clause.

Punctuation Unit 2

Unit Objective

Discriminative use of comma to separate parts of a geographical address.

Limits

S+	S-
1. Any combination of street address: one word name with number multiple words using avenue, street, road, boulevard, lane place, drive 2. Cities: one word multiple words 3. States or provinces 4. Countries	Compound words and adjective phrases which include an S+ component e.g., shady street; one part addresses.

Sub-objective 1

Discriminative tact of comma.

Instructional Cues

This is a comma (,).

Eliciting Cues

Which word has a comma?

Limits

S+	S-
,	. ,

Sub-objective 2

Discriminative tact of street addresses as one part of a geographical address

Instructional Cues

1. The number and name of a street is one part of an address.
2. The names of some streets have more than one word.
3. The kind of a street is not part of an address.

Eliciting Cues

1. Show whether each is part of an address.
2. Show how many parts in each.

Limits

S+	S-
1. Name of street with number 2. One word names: avenues, street, road, boulevard, lane, place, drive 3. Multiple word names	Compound words and adjective phrases which include an S+ component

Sub-objective 3

Discriminative tact of town or city as one part of a geographical address.

Instructional Cues

1. The name of a town or city is one part of an address.
2. The name of some cities have more than one word.
3. The kind of a city is not part of an address.

Eliciting Cues

1. Show whether each is part of an address.
2. Show how many parts in each.

Limits

S+	S-
1. One word names: city town village 2. Multiple word names	Compound words and adjective phrases which include an S+ component

Sub-objective 4

Discriminative use of comma to separate street address and city.

Instructional Cues

Rule 4: Use a comma after each part of an address that has more than one part.

Eliciting Cues

1. Make your mark below the line if a comma is needed.
2. Make your mark above line if a comma is not needed.

Limits

S+	S-
Any combination of parts listed under limits of 2 and 3 above.	1. One part addresses: street address city 2. Compound words and adjective phrase which include an S+ component.

Sub-objective 5

Discriminative tact of state as one part of geographical address.

Instructional Cues

1. The name of a state is also one part of an address
2. The kind of a state is not part of an address.

Eliciting Cues

Show whether each is part of an address.

Limits

S+	S-
All States	Adjective phrases including the word state or an S+ component.

Sub-objective 6

Discriminative use of comma to separate state as part of address.

Instructional Cues

None

Eliciting Cues

Show whether a comma is needed

Limits

S+	S-
All states	Compound words or adjective phrases which include an S-component one part address

Sub-objective 7

Discriminative use of comma to separate foreign cities, provinces, and countries.

Instructional Cues

The name of a country is also part of an address.

Eliciting Cues

1. Show whether each is part of an address.
2. Show whether a comma is needed.

Limits

S+	S-
All foreign countries, major foreign cities, and labeled provinces	1. Compound words and adjective phrases which include an S+ component 2. One part addresses

Punctuation Unit 3

Unit Objective

Discriminative use of commas to separate parts of a date.

Limits

S+	S-
Day Day of month Month Year	Compound words and adjective phrases which include an S+ One part dates

Sub-objective 1

Discriminative tact of days of week as part of a date.

Instructional Cues

1. The name of a day of the week is one part of a date.
2. The kind of a day is not part of a date.

Eliciting Cues

1. Show whether each is the name of a day of the week.
2. Show whether each is part of a date.

Limits

S+	S-
Seven days of week	Compound words and adjective phrases which include an S+ component

Sub-objective 2

Discriminative tact of day of a month as part of a date.

Instructional Cues

The name of a day of a month is one part of a date.
The name of a day of a month has the month and a number.

Eliciting Cues

Show whether each is the name of a day of the month.

Limits

S+	S-
All days of year	1. Number without month 2. Compound words and adjective phrases which include an S+ component

Sub-objective 3

Discriminative use of comma to separate name of day and day of month.

Instructional Cues

Rule 5: Use a comma after each part of a date written together. Do not use a comma if the parts of a date are separated by other words.

Eliciting Cues

Show whether a comma is needed.

Limits

S+	S-
Any combination of limits in objectives 1 and 2 above.	

Sub-objective 4

Discriminative tact of year as part of a date.

Instructional Cues

1. The name of a year is part of a date.
2. The kind of year is not part of a date.

Eliciting Cues

Show whether each is part of a date.

Limits

S+	S-
Any year	Compound words or adjective phrases which include an S+ component

Sub-objective 5

Discriminative use of commas to separate day of month and year.

Instructional Cues

The name of a month without a day is one part of a date.

Eliciting Cues

Show whether a comma is needed.

Limits

Any combination of limits of objectives 2 and 3 above.

Punctuation Unit 4

Unit Objective

Discriminative use of commas to separate parts of a series.

Limits

S+	S-
1. Words nouns verbs adjectives adverbs 2. Phrases verb adjective adverb prepositional 3. Series of 3 to 5 items, with and without and or or in context of simple and complex sentences.	One or two items

Sub-objective 1

Discriminative tact of series as a list of three or more items.

Instructional Cues

1. A series is a list of three or more items.
2. The parts of a series may have more than one word. So far and or or always come just before the last part of the series. Sometimes we have a series without and or or.
3. These words are never counted as part of a series: the, a, an, that, these, those, very.

Eliciting Cues

Show whether each sentence has a series.

Limits

All of unit limits

Sub-objective 2

Discriminative use of commas to separate parts of a series

Instructional Cues

Rule 6: Use a comma after each part of a series except the last.

Eliciting Cues

Show whether a comma is needed.

Limits

All of unit limits

Punctuation Unit 5

Unit Objective

Discriminative use of apostrophe in possessives.

Limits

S+	S-
Singular and plural possessives with and without s endings.	1. Non-possessives ending in s 2. Possessive pronouns

Sub-objective 1

Discriminative tact of possessive word and non-possessive word ending in s.

Instructional Cues

1. To find out if a word shows ownership, ask yourself two questions:
   First, are you told what is owned?
   Second, are you told who owns it?
   If the answer to both questions is "yes," the word shows ownership.
2. Sometimes the thing that is owned is not really the property of the owner. It still shows ownership (example shown).

Eliciting Cues

Does the underlined word show ownership?
Are you told what is owned?
Are you told who owns it?

Limits

All of unit limits

Sub-objective 2

Discriminative tact of singular and plural possessive.

Instructional Cues

1. Singular means one.
2. Plural means more than one.
3. To decide whether a word is singular, ask yourself,
   "Would I say is or are?"
4. If the answer would be is - the word is singular.
   is = singular
5. If the answer would be are - the word is plural.
   are = plural.

Sometimes the only way you can tell if a word is singular or plural is by the other words.

Eliciting Cues

1. Mark each word to show if it would be is or are and to show if it is singular or plural.
2. Show whether each word is singular or plural.
3. Mark which shows singular ownership, which shows plural ownership and which does not show ownership.

Limits

S+	S-
Singular and plural possessives with and without s endings.	Non-possessives ending in s

Sub-objective 3

Discriminative tact that possessive words need an apostrophe.

Instructional Cues

Rule 7: Use an apostrophe to show ownership.

First decide if the word shows ownership. If it shows ownership, it needs an apostrophe. If it does not show ownership, it does not need an apostrophe.

Limits

S+	S-
Singular and plural possessives with and without s endings	Non-possessives ending in s

Sub-objective 4

Discriminative insertion of apostrophes in singular and plural possessives.

Instructional Cues

1. To show that an ownership word is singular, use 's.
2. To show that an ownership word is plural, use s'.
3. A few plural words do not end in s. Use 's for these, just as for singular words.

Eliciting Cues

Show if each punctuation is correct.

Limits

S+	S-
Singular and plural possessives with and without s endings.	Non-possessives ending in s.

Sub-objective 5

Discrimination of possessive pronouns as words that are never written with an apostrophe.

Instructional Cues

(List of possessive pronouns.) These words show ownership, but they are never written with an apostrophe.

Eliciting Cues

Show whether each punctuation is correct.

Limits

All of unit limits

Punctuation Unit 6

Unit Objective

Discriminative use of apostrophe in contractions.

Limits

S+	S-
All contractions	Non-contractions with similar letter structure.

Sub-objective 1

Discriminative tact of contractions.

Instructional Cues

A word that is made by putting two words together and leaving out a letter is called a contraction.

Eliciting Cues

Which is a contraction?

Limits

All of unit limits.

Sub-objective 2

Discriminative use of apostrophe in contractions.

Instructional Cues

Rule 8: Use an apostrophe in place of missing letters in a contraction.

Eliciting Cues

Is the underlined word correct?

Limits

All of unit limits.

Punctuation Unit 7

Unit Objective

Discriminative use of period following abbreviations and initials.

Limits

S+	S-
All abbreviations and initials so tacted states quantities addresses dates directions titles time organizations	Short words which are not abbreviations or initials.

Sub-objective 1

Discriminative tact of abbreviations

Instructional Cues

An abbreviation is a shortened word.

Eliciting Cues

Show whether each is an abbreviation

Limits

S+	S-
All abbreviations so tacted	Short words

Sub-objective 2

Discriminative tact of initial

Instructional Cues

An initial is an abbreviation for a person's name.

Eliciting Cues

Show whether each is an abbreviation.

Limits

S+	S-
All initials	Short names and nicknames

Sub-objective 3

Discriminative use of period following abbreviations and initials.

Instructional Cues

Rule 9: Use a period after initials and abbreviations.

Elciting Cues

Show whether each is punctuation correctly.

Limits

All of unit limits.

Punctuation Unit 8

Unit Objective

Discriminative use of underscoring and quotation marks.

Limits

S+	S-
All titles so tacted	Adjective phrases

Sub-objective 1

Discriminative tact of underscore and quotation mark symbols.

Instructional Cues

None

Eliciting Cues

1. Which title is underlined?
2. Which title has quotation marks around it?

Limits

All titles so tacted.

Sub-objective 2

Discriminative tact of titles

Instructional Cues

1. The name of a book is a title.
2. The kind of a book is not a title.
3. There are other kinds of titles.

Eliciting Cues

Show whether each is a title.

Limits

S+	S-
All titles	Adjective phrases

Sub-objective 3

Discriminative use of underscoring and quotation marks.

Instructional Cues

Rule 10: Underline titles of books, magazines, and newspapers.
Rule 11: Use quotation marks around titles of poems, articles, and chapters, and songs.

Eliciting Cues

1. Show which should be underlined and which should be in quotation marks.
2. Show which should be underlined, which should be in quotation marks, and which should have neither.
3. Show whether the punctuation is right or wrong.

Limits

S+	S-
All titles so tacted	Adjective phrases

CHAPTER IV

FINAL EXPERIMENTS

Capitalization Experiment

This experiment employed a factorial design to investigate two main effects. The first effect was a fixed factor at two levels:

1. Unit bypassing (branching) contingent on adequate Unit Test performance
2. No bypassing (non-branching) irrespective of Unit Test performance

The second effect was also fixed but at four levels:

1. Program + chemically treated Review Exercises + immediate total score feedback
2. Program + chemically treated Review Exercises + delayed total score feedback
3. Program + Review Exercises + delayed total score feedback
4. Program only

Each of the eight treatment combinations was randomly assigned to one fourth grade class from three schools in a large metropolitan elementary school district.

Experimental Materials

Programmed Text. A linear sequence of 612 frames was prepared divided into the 13 units shown in Table 23. The frames were mimeographed on 8½" X 11" paper and arranged into a programmed text of two books of approximately 100 pages each. A multiple choice response mode was used with the keyed responses mimeographed in a special ink containing a green dye which bled to show a color when dampened with a pen containing a water base solution. This is the same general process used with the chemically pretreated Review Exercises in Preliminary Experiment 5 and described in Appendix F.

Readiness Tests. The same measures of entering behavior used in Preliminary Experiment 3 and shown in Appendix D were used in the present experiment.

Criterion Achievement Test. The revised behavioral analysis provided the basis for a refined criterion measure. A test involving 65 sentences and 333 two-choice discriminations were constructed. The test, shown in Appendix G, sampled each unit as equally as possible and included both S+ and S- stimuli.

Unit Tests. Pre- and Post-Unit tests were constructed for each unit similar to those used in previous experiments. These were bound in the programmed text booklets in sequence with the programmed instruction. Answer spaces for the tests were not chemically treated.

Review Exercises. A cumulative review was prepared to follow each unit beginning with the second unit.

A sample unit including the Unit Tests, the Programmed Text, and Review Exercise is shown in Appendix H.

TABLE 23

Sequence of Unit Topics in Final Capitalization Program

1. Beginning of Sentence
2. "I"
3. Persons (including initials) and Pets
4. Days and Months (including abbreviations)
5. Holidays
6. Organizations
7. Relatives
8. Titles of People
9. Names of Places and Abbreviations
10. Sections and Directions
11. Titles of Books, Magazines, Songs, Newspapers, Poems
12. Nationalities, Races, and Adjective Form of Foreign Countries
13. Words Within Quotation Marks

Procedure

All classes were given the Readiness Tests the first day of the experiment, the Criterion Achievement Pretest the second day, and "How to Use a Programmed Text" the third day.

The program was started the fourth day. Pupils worked on the instructional program 30-50 minutes daily, working at their own pace so long as they did not exceed the group assignment for that day. The teacher was given written instructions, including a time schedule for conducting each day's group assignment. After the first three days, flexibility in scheduling was permitted; the only restriction placed on the teacher was that she consider each unit as an intact instructional block, i.e., if the class starts a unit all pupils must be given time to complete it during that period. Although most teachers ordinarily took but one unit a day, each teacher "doubled-up" at one time or another. Thus, the experiment was group paced between units of instruction and individually paced within units.

The sequence of procedures for each unit for pupils in the contingent bypassing treatments was as follows:

> 1. Pupils take the chemically treated Unit Pretest. Teacher reads correct answers, and each pupil scores his own test. If a pupil has one error or less, he bypasses the programmed text and goes to the Unit Posttest. If he has more than one error he responds to the chemically treated programmed text before taking the Unit Posttest.
>
> 2. The teacher scores each Unit Posttest as soon as a pupil completes it. If the pupil has one error or less he is given the Review Exercise appropriate to his assigned treatment group. If he has more than one error on the Unit Posttest he is required to repeat the programmed instruction (or respond for the first time if he previously passed the Unit Pretest) and respond to a fresh Unit Posttest. If he makes more than one error on the second attempt at the Posttest the teacher may use her discretion as to whether he moves on to the Review Exercise or repeats the unit program.

Pupils in the non-bypassing treatments followed essentially the same procedure except they responded to every frame in the programmed instruction, irrespective of their performance on the Unit Pre- and Posttest.

The specific procedures used for each of the Review Exercise treatments were as follows:

> 1. Chemical Treatment-Immediate Total Score. Pupils in this group responded to the pretreated Review Exercises. The pupil was instructed to total his score, record it at the top of the sheet, and turn the Exercises in to the teacher. The teacher would then enter the total score on a roster which was posted where all pupils could see it.

2. Chemical Treatment - Delayed Score. The pupils in this treatment followed the same procedures as above, except that they simply completed each pretreated Review Exercise and turned it in to the teacher. These were picked up daily by E for scoring in the Laboratory and were returned with total scores within one to three days. The teacher would then enter the total score on the class roster.

3. No Chemical - Delayed Score. Pupils responded to non-treated Review Exercises and turned them in to the teacher upon completion. These were picked up daily by E for scoring as in Treatment 2.

4. Program Only. Pupils responded to the programmed instructional material only.

All pupils were administered the Criterion Achievement Posttest the day following completion of the program.

Results

Adequacy of the Measures. Table 24 presents the descriptive statistics and Kuder-Richardson 21 reliability coefficients for the various measures used in the experiment, based on all Ss combined.

TABLE 24

Descriptive Statistics and Kuder-Richardson 21 Reliability Coefficients for Readiness, Criterion, and Review

Test	Mean	S.D.	KR 21 r_{xx}
Readiness Test I	18.58	4.46	.83
Readiness Test II	52.59	9.41	.94
Criterion Achievement Pretest	249.56	33.65	.95
Criterion Achievement Posttest	273.39	34.20	.96
Review Exercise #1	15.74	2.39	.69
Review Exercise #2	18.00	2.73	.80
Review Exercise #3	55.48	4.54	.85
Review Exercise #4	45.65	3.12	.79
Review Exercise #5	57.73	4.57	.87
Review Exercise #6	81.26	7.90	.90
Review Exercise #7	60.92	6.61	.80
Review Exercise #8	55.58	5.23	.77
Review Exercise #9	76.10	6.61	.85
Review Exercise #10	55.06	6.57	.82
Review Exercise #11	76.23	7.61	.83
Review Exercise #12	56.83	5.42	.80
Review Exercise #13	65.61	7.55	.84

None of the tests presented in Table 24 was used in making decisions with respect to S's instructional route. Readiness Tests I and II, along with the Criterion Achievement Pretest, were used as covariates in the analyses of covariance with the Criterion Posttest the dependent measure. The Review Exercises, although treated as tests as far as Ss were concerned, were instructional devices. As they were cumulative in their sampling, Review Exercise #13 most closely approximated the Criterion Achievement Posttest. The two measures correlate .73. Inspection of Table 24 indicates that the two criterion measures were highly reliable, and that the other measures were also quite adequate for their purposes.

As mentioned previously, the mean scores on the criterion instruments are somewhat "ballooned." Although the sampling is balanced, it seemed desirable to eliminate possible internal "cueing" by forcing S to make capitalization decisions in the more common and elementary areas even though the central intent of an item might relate to a more advanced topic. As it worked out, this served to "add a constant" to the total score.

Since unit bypassing is dependent upon performance on the short Unit Pre- and Posttests, it is critical that their reliabilities be sufficiently high to support reliable "skipping" decisions. Table 25 shows the Kuder-Richardson 21 reliability coefficients for the Unit Pre- and Posttest. As these tests were quite short, the strategy was that if S passed the pretest he still had to do as well on the posttest to be allowed to bypass the unit; this strategy had the effect of doubling the length of the Unit Test. There is some variability among the reliabilities, but in general their magnitude is more than adequate for the purpose of this experiment.

Another way of analyzing the adequacy of the Unit Pre- and Posttests as reliable decision makers is to look at the test performance of those Ss whose pretest performance made them eligible to bypass the unit. Table 25 also shows a comparison of the number of Ss who made criterion scores on the Unit Pretest with the number of these same Ss who bypassed the unit and went ahead to pass the Unit Posttest. This analysis indicates that it was probably wise

TABLE 25

Kuder-Richardson 21 Reliability Coefficients for Unit Pre- and Posttest, and Consistency of Bypassing Decisions

	KR 21 r_{xx}		Number Passing		Percent
	Pre	Post	Pre	Post	(Post/Pre)
1	.40	.63	39	31	79
2	.67	.84	74	64	86
3	.79	.77	89	86	97
4	.86	.74	65	41	63
5	.75	.87	36	19	53
6	.84	.67	15	10	67
7	.36	.59	17	6	35
8	.48	.51	76	41	54
9	.79	.87	32	24	75
10	.41	.56	18	5	28
11	.84	.86	32	27	84
12	.72	.62	50	44	88
13	.23	.48	28	25	89

to make S's bypassing contingent upon adequate performance on both Pre- and Posttest.

Analysis of Criterion Data. Table 26 shows the means and standard deviations for all measures used, by treatment classification. Readiness I, Readiness II, and Achievement Pretest scores were entered as covariates in a 2 X 4 factorial covariance analysis of the Criterion Achievement Posttest. Table 27 shows the Analysis. The F value of .36 for bypassing is not statistically significant. Therefore, it appears that there is no loss in instructional efficiency when Ss are allowed to bypass portions of the program on the basis of performance on psychometrically sound measures.

Analysis of bypassing data indicates that Ss assigned to the bypassing treatments bypassed a mean of 3.76 units of a possible 13. The distribution is positively skewed with a standard deviation of 2.54 units. The range for number of units skipped is from zero to nine. As previously pointed out, the decisions to bypass based on the Unit Pre- and Posttests were reliable and resulted in no loss of instructional efficiency.

TABLE 26

Descriptive Statistics for Measures Used, by Treatment Classification

Treatment	Readiness I		Readiness II		Achievement Pretest		Achievement Posttest		Review 13	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Bypassing										
1	19.40	4.38	54.17	6.92	257.20	36.89	289.20	25.63	69.90	6.70
2	19.17	3.79	54.07	8.44	254.77	32.62	284.57	24.27	65.37	7.50
3	19.10	3.67	52.60	11.41	253.07	23.79	268.20	34.11	64.34	6.86
4	19.04	3.71	53.46	8.32	246.36	33.43	265.24	27.44		
Total Bypassing	19.18	3.86	53.46	8.59	253.13	31.80	277.30	29.60	66.56	7.36
Non-Bypassing										
1	19.00	4.20	55.59	6.10	260.62	27.39	283.59	33.09	66.76	6.57
2	19.10	3.40	48.20	8.97	242.20	32.82	268.55	25.70	63.10	5.06
3	18.58	4.66	55.10	7.02	253.32	33.31	268.00	39.20	62.05	10.41
4	15.32	6.15	47.36	12.99	233.68	42.12	253.85	46.47		
Total Non-Bypassing	17.86	5.01	51.55	9.97	247.48	35.67	268.69	38.65	64.37	7.67
Grand Total	18.58	4.46	52.59	9.41	249.56	33.65	273.39	34.20	65.61	7.55

TABLE 27

Analysis of Covariance of Achievement Posttest

Source of Variation	Degrees of Freedom	Residuals Sums of Squares	 Mean Squares	F
Bypassing	1	153.88	153.88	.36
Review Treatment	3	6924.69	2308.23	5.43*
Interaction	3	431.70	143.90	.33
Within	149	63336.47	425.08	

* P <.01 level

The F value for Review Treatment (5.43) is significant beyond the .01 level, and indicates that a difference does exist. Table 28 shows the adjusted means for the review treatments. Considering the Criterion Achievement Test, the difference between treatment one and two is not significant, but both one and two made significantly (P <.05) higher scores than either treatment three or four.

TABLE 28

Adjusted Means for Review Treatments

Treatment	Adjusted Means Criterion Achievement Test	 Review Exercise 13
1	280.50	66.89
2	277.27	64.64
3	265.97	61.70
4	268.11	---

The F value for interaction (.33) is not statistically significant, indicating that each of the review treatments had a similar influence on performance irrespective of its bypassing classification.

The results of this analysis demonstrate clearly that Ss are sensitive to differential reinforcement contingencies. Providing S with review exercises and assuming that they are powerful enough by themselves to control careful attention behavior is without support. As a matter of fact, this experiment suggests that there is little advantage to using review exercises at all unless provisions are made for a reinforcement contingency related directly to behavior on the review exercise; in this study it was immediate knowledge of results. Note that chemically treating the review exercises and delaying the total score feedback is superior to no chemical treatment and delayed feedback. Although not statistically significant, there does appear to be a slight advantage to tightening student control by providing both chemical treatment and immediate total score feedback.

Table 29 shows the results of a similar analysis using Review Exercise 13 as the dependent variable. Review Exercise 13 is used as a dependent variable since in the final revision the unit achievement (review) exercises were modified to reflect the cumulative nature of shaping the global response class. This would mean, then, that Unit Achievement Exercise Number 13 should closely approximate the criterion instrument in terms of sampling the terminal behavior.

TABLE 29

Analysis of Covariance of Review Exercise 13

Source of Variation	Degrees of Freedom	Residuals Sums of Squares	 Mean Squares	F
Bypassing	1	84.13	84.13	2.38
Review Treatment	2	298.03	149.01	4.22*
Interaction	2	115.66	57.83	1.63
Within	111	3918.30	35.30	

* $p < .05$

The results are identical to those of the preceding Criterion Achievement Posttest analysis; the only significant difference ($F_{2,\ 111} = 4.22$) was for Review Exercise Treatments. Table 28 shows the adjusted Review Exercise 13 means.

When the bypassing and non-bypassing classifications are collapsed and the three treatments are analyzed, differences between the Chemical Treatment - Immediate Total Score Group (Treatment 1) approaches significance with Treatment 2 and significant with Group 3 beyond the .05 level. Again, these findings parallel the Criterion Achievement Posttest analysis.

As described above, both the programmed instruction and the criterion measures present (1) stimuli that should be capitalized and (2) stimuli which should control non-capitalization behavior. These were distinguished as S+ and S-, respectively, in each item form. Table 30 shows the results when the criterion tests are scored in terms of performance on S+ and S- items. The interesting point in this comparison is that Ss made greater relative gain in learning what not to capitalize than they did in learning what to capitalize. At the same time, the standard deviations indicate increased homogeneity of performance on S+ tasks, and increased variability on the S- tasks. Although we would not have predicted such a difference, it is quite clear that Ss were sensitive to the program's attempt to shape the whole concept. As mentioned in Chapter III, and as reflected in our Item Forms, total concept acquisition necessitates careful attention both to the stimulus classes controlling capitalization behavior and also to the stimulus classes controlling non-capitalization behavior.

TABLE 30

S+ and S- Part Scores on Achievement Pre- and Posttests

	S+		S-	
	Mean	S.D.	Mean	S.D.
Pretest	129.59	24.23	124.72	30.21
Posttest	136.51	29.06	139.93	37.94

Fractions Experiment

This experiment involved three treatment variations:

1. Chemically Treated Review Exercises - Contingent Bypassing
2. Chemically Treated Review Exercises - No Bypassing
3. No Review Exercises - Contingent Bypassing

Four fifth grade classes with a total of 135 pupils from a single elementary school participated in the experiment. Two classes were randomly assigned to treatment 1 and one class was assigned to each of the other treatments.

Experimental Materials

Programmed Text. For the final experiment, an 1175-frame revision of the linear program utilized in Preliminary Experiment 4 was prepared. The format was the same as that described in Preliminary Experiment 4, with the exception that the back side of each sheet, opposite the correct responses, was darkened with memeograph ink in order to prevent cheating which might be cued because of the translucency of the ditto paper.

The content of the final revision of the programmed text was based on the item forms shown in Table 21. Units 22, 24, and 25 of the initial program were combined into a single unit (Unit 21) covering the reducing of fractions to lowest terms. Thus, a multiple unit sequence based on homogeneity of stimuli was replaced with a single unit sequence which homogenized the response characteristics. Units 20, 21, 23, 26, 27, and 29 of the preliminary program were combined in Unit 23 to bring all types of addition and subtraction problems into a single unit, based again on response characteristics rather than on stimulus characteristics.

Readiness Test. The 42-item test used in the preliminary experiments was also used in the final study (Appendix A).

Criterion Achievement Tests. The criterion tests used in Preliminary Experiment 4 were revised to conform to the objectives of the new program. Two 60-item forms, parallel in content, were used as pre- and post experiment achievement measures (Appendix I). The number of items was increased from 50 to 60 to sample the 23 units as equally as possible. A multiple choice response mode was employed, with Ss indicating their answers on standard IBM answer sheets.

Unit Tests. The short pre- and posttests for each of the 23 units of the program were essentially the same in content as those of Preliminary Experiment 4, with the exception that where the content of the program was modified for the final study, the tests were revised to conform to the new program. In addition, all items were presented in a multiple choice response mode. The pre- and posttests for Unit 22 appear in Appendix J.

Review Exercises. For each unit of the program, a review exercise was prepared. These exercises, consisting of from 9 to 33 items, represented a cumulative sample of the population of items from all units previously covered. Each Review Exercise was, in effect, a successive approximation of the final Criterion Achievement Test. Response mode was changed from constructed to multiple choice, and the chemical feedback technique described previously was used.

Procedures

The procedures followed in this experiment paralleled those employed in the capitalization experiment.

The specific procedures used for each of the Review Exercise Treatments were as follows:

1. Chemical Treatment - Contingent Bypassing. Pupils in this group responded to the pretreated Review Exercises. The pupil was instructed to total his score, record it at the top of the sheet, and turn the exercise in to the teacher. Pupils in this treatment were allowed to bypass a program unit contingent on adequate Unit Test performance.

2. Chemical Treatment - No Bypassing. Pupils in this group responded in identical fashion to Treatment 1, except they were not allowed to bypass a program unit, irrespective of Unit Test performance.

3. No Review Exercises - Contingent Bypassing. Pupils in this group did not respond to Review Exercises, but were allowed to bypass a program unit contingent on adequate Unit Test performance.

Results

Adequacy of Measures. Table 31 presents the descriptive statistics and Kuder-Richardson 21 reliability coefficients for the various measures used in the experiment, based on all Ss combined.

TABLE 31

Descriptive Statistics and Kuder-Richardson 21 Reliability Coefficients for Readiness, Criterion, and Review Measures

Test	Number of Items	Mean	S.D.	KR 21 r_{xx}
Readiness	42	38.24	4.21	.83
Criterion Achievement Pretest	60	12.96	6.48	.77
Criterion Achievement Posttest	60	38.10	11.25	.91
Review Exercise #1	9	8.73	.57	.22
Review Exercise #2	12	11.78	.66	.55
Review Exercise #3	15	14.63	.93	.63
Review Exercise #4	12	11.76	.77	.66
Review Exercise #5	12	11.18	1.02	.29
Review Exercise #6	12	11.28	.89	.16
Review Exercise #7	12	10.85	1.25	.37
Review Exercise #8	12	11.22	1.65	.80
Review Exercise #9	10	9.37	.76	.25
Review Exercise #10	12	11.12	1.25	.52
Review Exercise #11	14	12.68	1.42	.44
Review Exercise #12	20	18.86	1.01	.57
Review Exercise #13	20	18.66	1.48	.45
Review Exercise #14	20	17.71	2.54	.72
Review Exercise #15	20	17.50	2.28	.61
Review Exercise #16	20	15.73	3.28	.73
Review Exercise #17	29	23.09	4.12	.75
Review Exercise #18	25	19.88	3.76	.74
Review Exercise #19	25	20.29	4.36	.83
Review Exercise #20	25	21.24	2.93	.66
Review Exercise #21	20	15.70	3.28	.72
Review Exercise #22	25	18.83	4.38	.79
Review Exercise #23	33	25.34	6.92	.91

The reliability coefficients are quite respectable, particularly for the Criterion Achievement Posttest and the final Review Exercises. The low reliability coefficients for the early Review Exercises are a function of restricted variance resulting from the uniformly high level of performance.

Since unit bypassing was contingent upon performance on the short Unit Pre- and Posttests, it is critical that their reliabilities be adequate for the task. Restricted variance on the Unit Pre- and Posttests made it unreasonable to analyze their reliability using conventional procedures. Table 32 shows a comparison of the number of Ss who made criterion scores on the Unit Pretest with the number of these same Ss who went ahead to pass the Unit Posttest and bypass the unit. Although this analysis indicates that it is probably wise to make S's unit-bypassing contingent on passing two unit tests, yet on only five units did the percentage of Ss passing the posttest fall below 80%.

TABLE 32

Consistency of Unit Bypassing Decisions

Unit	Number Passing Pretest	 Posttest	Per cent (Post/Pre)
1	116	115	99
2	73	69	95
3	120	118	98
4	129	126	98
5	34	32	94
6	106	102	96
7	123	120	98
8	77	72	94
9	69	67	87
10	97	95	98
11	131	131	100
12	126	123	98
13	72	71	99
14	16	10	63
15	10	2	20
16	34	21	62
17	33	27	82
18	51	43	84
19	90	83	92
20	51	34	83
21	24	19	29
22	25	17	68
23	10	8	80

Analysis of Criterion Data. Table 33 presents descriptive statistics for the control and criterion measures used in this experiment. Readiness Test mean scores indicate that, as a group, Ss were prepared to enter the program. Most Ss approached within chance of a perfect score.

TABLE 33

Descriptive Statistics for Fractions Criterion Measures

	Readiness Test		Criterion Pretest		Criterion Posttest	
Treatment	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	38.22	4.75	12.13	6.22	40.34	10.02
2	39.55	3.15	13.91	6.09	38.41	11.35
3	37.03	5.49	13.68	7.85	33.00	10.25

Mean scores on the Criterion Achievement Pretest show that Ss were uniformly quite naive with respect to program content. Certainly when Criterion Achievement Posttest is compared in a relative context with the Criterion Pretest, all groups improved considerably.

Table 34 presents a summary of the analysis of covariance of the Criterion Achievement Posttest results, using the Readiness Test and Criterion Achievement Pretest as covariates. Although the obtained means are ordered in terms of the degree of control exercised over the pupil's behavior, the F is not statistically significant.

TABLE 34

Analysis of Covariance of Fractions Criterion Achievement Posttest

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F
Review Treatment	2	50.76	25.45	1.75
Within	125	1806.62	14.45	

Punctuation Experiment

The design of this experiment was closely analogous to that of the Capitalization Experiment. A 2 X 4 factorial design was employed with bypassing vs. non-bypassing as one fixed effect and Review Exercise contingencies as the other fixed effect. The treatments of the Review Exercise effect differed slightly, however, from those investigated in the Capitalization Experiment. The four levels of the effect in this experiment were as follow:

1. Program + Review Exercises with immediate knowledge of results
2. Program + Review Exercises with short delay in knowledge of results
3. Program + Review Exercises with long delay in knowledge of results
4. Program only

Each of the eight treatment combinations was randomly assigned to one fourth grade class from three schools in a single suburban elementary school district.

Experimental Materials

Programmed Sequences. In accordance with the revised behavioral analysis a programmed instructional sequence was prepared for each item for shown in Table 22. A multiple choice response mode was used, with the keyed responses pretreated using the two-color process described in Appendix F. The programmed sequence was reproduced on 8½" X 11" mimeograph paper and bound with the Unit Pre- and Posttests in a separate booklet for each unit. A sample unit is shown in Appendix K.

Readiness Tests. The same measures of entering behavior used in Preliminary Experiment 5 were used in the present experiment.

Criterion Achievement Test. The revised behavioral analysis provided the basis for a refined criterion measure. A test involving 95 sentences containing 168 discriminative responses was constructed. The test, shown in Appendix L, sampled both S+ and S- stimuli from each unit.

Unit Tests. The Unit Pretests followed the same general strategy as in the previous experiment. They were not chemically pretreated. The Unit Posttests were based on a different strategy. They were much longer, ranging in length from 50 to 102 responses, and the answer spaces were pretreated. Pupils were instructed to continue to respond to the Posttest until they obtained 12 keyed responses in sequence.

Review Exercises. A cumulative Review Exercise was prepared to follow each unit beginning with the second unit.

Procedure

Aside from the difference in the Unit Posttest contingency, the bypassing and non-bypassing procedures for each unit directly paralleled those employed in the Capitalization Experiment.

The procedures used in each of the Review Exercise treatments were as follows:

1. Immediate Knowledge of Results. Pupils responded to pretreated Review Exercises. After completing this Exercise, the pupil totaled his score, recorded it at the top of the sheet, and turned the Exercise in to the teacher.

2. Short Delay in Knowledge of Results. Pupils first responded to the Review Exercise by circling the responses with a pencil. After completing the Exercise, the pupil went back and marked the pretreated answer spaces with his pen to score the Exercise. He then totaled his score and turned the Exercise in to the teacher.

3. Long Delay in Knowledge of Results. Pupils responded to non-treated Review Exercises and turned them in to the teacher upon completion. The Exercises were picked up daily by E for scoring in the Laboratory and were returned with total scores within one to three days.

4. Program Only. Pupils responded to the programmed instructional materials only.

All pupils were administered the Post Experiment Criterion Achievement Test the day following completion of the program.

Results

Adequacy of the Measures. Table 35 presents the descriptive statistics and Kuder-Richardson 21 reliability coefficients for the

TABLE 35

Descriptive Statistics and Kuder-Richardson 21 Reliability Coefficient for Criterion Measures

Test	Bypassing Treatment Mean	Bypassing Treatment S.D.	Bypassing Treatment KR21	Non-Bypassing Treatment Mean	Non-Bypassing Treatment S.D.	Non-Bypassing Treatment KR21
Criterion Achievement Pretest	113.14	21.24	.92	109.12	21.93	.93
Criterion Achievement Posttest	123.50	24.02	.95	114.07	25.42	.95
Review Exercise #1	66.26	13.08	.91	65.59	11.09	.87
Review Exercise #2	55.09	9.65	.85	50.28	10.23	.85
Review Exercise #3	57.33	11.67	.89	54.55	11.29	.87
Review Exercise #4	72.22	14.01	.89	68.93	14.65	.90
Review Exercise #5	80.05	17.89	.94	76.17	18.52	.94
Review Exercise #6	104.22	21.12	.95	96.59	21.74	.94
Review Exercise #7	87.08	17.81	.92	76.05	20.92	.94

various measures used in the experiment, computed separately for pupils in the bypassing and non-bypassing treatments. As in the previous experiments, the reliability coefficients are quite respectable.

TABLE 36

Reliability Data for Unit Pre- and Posttests

Unit	Pretest KR 21	Number Passing Pretest	Number Passing Posttest	Per cent (Post/Pre)
1	.75	61	53	87
2	.92			
3	.69			
4	.77			
5	.32	5	3	60
6	.58	72	49	68
7	.68	65	43	66
8	.42	7	2	29

Table 36 presents the reliability coefficients for the Unit Pretests based on the total group. The nature of the Posttests made it impossible to analyze their reliability using conventional procedures. However, with the exception of Units 2-4, it was possible to determine the consistency of the bypassing decision for those pupils who achieved adequate Pretest performance. These frequency counts are indicated in the table.

Analysis of Criterion Data. Table 37 presents descriptive statistics for the control and criterion measures used in the experiment. Table 38 presents a summary of the analysis of covariance of the Achievement Posttest results, using the two Readiness Tests and the Achievement Pretest as covariates. The analysis indicates that both bypassing and Review Exercise contingencies had a statistically significant effect on Achievement Posttest performance. The adjusted

TABLE 37

Descriptive Statistics for Measures Used, by Treatment Classifications

	Readiness I		Readiness II		Achievement Pretest		Achievement Posttest	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Bypassing								
1	20.18	4.09	54.82	7.73	104.27	25.10	126.86	25.54
2	20.45	3.69	54.73	8.65	114.90	18.55	125.77	28.06
3	19.32	3.30	55.54	5.33	117.63	16.47	127.18	21.33
4	21.59	3.74	56.14	4.88	115.09	19.92	118.67	33.67
Non-Bypassing								
1	19.27	4.66	51.68	12.43	112.68	21.17	123.09	24.83
2	19.59	4.40	50.09	16.11	109.86	16.20	114.36	26.14
3	18.73	4.47	56.09	3.54	108.86	21.43	100.50	25.33
4	17.86	5.66	47.05	11.39	102.04	25.07	111.14	22.44

TABLE 38

Analysis of Covariance of Achievement Posttest

		Residuals		
	Degrees of Freedom	Sums of Squares	Mean Squares	F
Bypassing	1	3123.89	3123.89	9.39^{**}
Review Treatment	3	3596.62	1198.87	3.61^{*}
Interaction	3	2442.78	814.26	2.45
Within	165	54874.72	332.57	

* $p < .05$
** $p < .01$

means for the levels of each effect are shown in Table 39. The bypassing treatment is superior to the non-bypassing treatment. The greater the control exercised by the Review Exercise contingencies, the better the performance.

TABLE 39

Adjusted Treatment Means

Bypassing	Non-Bypassing
121.49	117.94

Review Exercise Treatment			
1	2	3	4
123.69	118.68	113.03	116.10

Summary

In general the experiments demonstrate that the greater the control exercised by the instructional materials, the greater the learning. However, there is still wide variability in performance in each of the three experiments. This variability was sufficiently great in the Fractions Experiment to sustain the null hypothesis of differences among the treatment means even though the means were ordered in the predicted direction.

The parallel designs employed in the Capitalization and Punctuation Experiments permit analysis of the data using Page's L-test (1963) to test for a monotonic relationship among the treatment groups. Table 40 presents the rankings necessary to test the hypothesis that the bypassing contingency effected greater learning than non-bypassing. The ranks indicated are based on achievement gain; the difference between Pre and Post Achievement Test means for each replication. The data permit rejection of the null hypothesis at the .01 level; we may conclude that there exists a significant amount of agreement between the predicted superiority of the bypassing treatment and the experimental rankings in the various replications.

TABLE 40

Ranking Matrix for Bypassing Contingencies

	Ordered Treatments	
Rankings	Bypassing	Non-Bypassing
Capitalization		
Treatment 1	1	2
Treatment 2	1	2
Treatment 3	1	2
Treatment 4	2	1
Punctuation		
Treatment 1	1	2
Treatment 2	1	2
Treatment 3	1	2
Treatment 4	2	1

$L = 34$, $L_{critical} = 16$ $p < .01$

An analogous test is shown for the contingencies surrounding the Review Exercises. Again, as the data in Table 41 indicates, the null hypothesis of a monotonic relationship is rejected at the .01 level.

TABLE 41

Ranking Matrix for Review Exercise Contingencies

	Ordered Treatments			
Rankings	1	2	3	4
Capitalization				
Bypassing	1	2	4	3
Non-Bypassing	2	1	4	3
Punctuation				
Bypassing	1	2	3	4
Non-Bypassing	1	3	4	2

$L = 114$ $L_{critical} = 106$ $p < .01$

The high verifiability of the general findings from experiment to experiment has impressed (and sometimes surprised) us throughout the course of the research. This applies not so much to some of the fine grain details concerning programming techniques as it does to variables which the experimental data rather than our initial preconceptions have proved to be "heavy-weight" effects.

We find that this replicability extends to recent research outside our Laboratory where the investigation has followed similar direction. The exploratory tutorial investigation at System Development Corporation (Silberman, H., Coulson, J., Melaragno, R., and Newmark, 1964) for example generated three principles which are quite consistent with our findings.

> The principles are: (1) every skill included in the program objectives, and every subskill that logically contributes to those objectives, should be explicitly covered by the program unless it exists in the student's entry repertoire; (2) any materials that do not contribute to the program objectives, as indicated by logical analysis, should be eliminated; and (3) the student should be required to demonstrate mastery of each component subskill before he is allowed to advance to new topics that are based on the earlier materials (p. 41).

Similarly Glaser's (1964) research in developing "clock reading" behavior led him into the same kinds of successive approximations which we have reported. Even the case study reports of informal "field" use of programmed materials (Schramm, 1964) contain observations which verify, or are at least compatible with, the findings generated in this project.

This "replicability," although on an informal level to date, is encouraging; particularly, since the aspects of the research that are replicated are frequently not those which a given investigator was trying to "push." It suggests that the identification of functional relationships in instruction is a feasible endeavor and that the successive approximations inherent in programmed instructional research have some prospect of isolating these relationships.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objective of this project was to investigate methods of accomodating conventional measurement procedures to the unique requirements of programmed instruction. The results of the experiments demonstrate that formal measurement can indeed fulfill an important role in programmed instruction. However, the full exploitation of this role requires control over non-psychometric as well as psychometric variables. The purely technical aspects of measurement pose no great difficulty. The research demonstrates that conventional psychometric procedures can readily be adapted to generate measures which provide an adequate base for instructional decisions. The trick is to effect these decisions.

The item form concept provides a neat system for "blueprinting" tests that meet all of the requirements of the psychometric concept of content validity and at the same time define the behavioral structure of a subject matter domain. Although the development of item forms requires much greater effort than is typically devoted to the preliminary planning of a standardized test battery, the research demonstrates that the procedure is feasible and sufficiently flexible to serve a number of purposes.

Neither does the psychometric concept of reliability appear unduly difficult to apply. In measuring a response class with breadth conveniently suitable for instructional purposes, adequate reliability appears to come "naturally." Conventional reliability formulas may underestimate the consistency of the measures when the instructional program is successful in shaping performance at a uniformly high level of proficiency. However, the research demonstrates that the reliability of instructional decisions can readily be checked by simple frequency counts.

Thus, without great difficulty it is possible to generate a series of reliable, structured, diagnostic tests that provide the potential for quality control of learning directly analogous to the kind of product control exercised in industry. However, this research demonstrates that initiating quality control in the classroom is no simple matter. Criterion-referenced measures simply are not available for classroom use. And even if they were, we would have no assurance that pupil performance would be much different, for such measures, though necessary, are not sufficient to insure a criterion-referenced classroom climate. Formal education in all of its intricacy is so permeated with a relative conceptualization that an absolute approach is alien, if not abhorrent, to most elements of the educational establishment as well as to large segments of general society.

The empirical referents of the present research provide a springboard for considering the relative vs. absolute issue without becoming enmeshed in emotional respondents. Contrary to popular conception, the measurement of individual differences is basic to both approaches. The approaches diverge only after individual differences have been identified through some sort of measurement procedure, not before.

Consider any instructional objective. One gives a pretest to a group of pupils and obtains scores which range from "high to low." Now we arrive at the crossroads. What action is to be taken on the basis of the test results? The norm referenced, relative approach chalks up the variability to individual differences; individual differences were there before instruction and because they are still there, they must be inherent in education. Since they were fully expected, the individual differences are simply recorded, and instruction designed to fit the needs of the group follows. A posttest is then administered to determine the effects of instruction. The conventional standard of instructional success in the relative context is gain in achievement from pretest to posttest. If a positive group gain is demonstrated, the instructor can be well satisfied. If the gain is greater than that typically achieved, he can be exultant. Following the posttest, another pretest, and the cycle is repeated.

Since no serious questions are raised concerning the absolute degree of proficiency obtained, this is a comfortable situation for all concerned. However, it tyrannically commits instruction to inefficiency in terms of absolute standards. With each cycle, some pupils learn very quickly, while others fail to learn. Yet the instructional cycle continues. Variations in individual differences increase the longer instruction is pursued, as many pupils become more and more proficient in discovering "how to succeed in school without really learning" and less and less proficient in achieving desired curricular objectives.

Elaborate steps are taken to keep the variability in achievement under control. "Spiralling" instructional materials give pupils who failed initially to acquire the behavior a second, third, and nth chance, without unduly insulting pupils who have already achieved proficiency. "Enrichment materials," "remedial materials," "developmental materials," "multilevel materials," etc., are all intended to perform the same function even though in operation they typically amount to little more than intraverbal substitutes for efforts that would be highly desirable were they not so effortful. (It is significant to note that the latest report to programmed instruction usage in public schools suggests that self instructional materials are proving most popular as "remedial" and "enrichment" materials (Schramm, 1964.)

Let us now consider how our hypothetical pretest results would be interpreted in an absolute context. If the pretest reflects a defined response class, it can be used to indicate which pupils have already acquired the behavior of interest and which have not. For a pupil who already has the response class in his repertoire, testing can be continued until he reaches a response class he has not yet acquired. For a pupil who has not acquired the original behavior of interest, instruction focuses on this behavior. This instruction is followed by a posttest. If the posttest performance is adequate, the pupil continues on to the next pretest. If it is not adequate, he does not go on. He is given additional instruction until his posttest performance is adequate.

It is sometimes assumed that the relative orientation actually accomplishes the objectives of the absolute orientation; that it simply involves a different strategy. Persons attempting to defend this view, point to the ample provision in every well-developed textbook for review problems, remedial exercises, special assignments, etc. However, these labels do not in any way insure either the utility or practical feasibility of these materials. In practice, such materials fall short on at least two counts. First, the absence of content referenced criterion measures makes it impossible to diagnose individual instructional requirements or to evaluate individual achievement with the precision required to implement an absolute orientation. Second, sheer time limitations make it impossible for the teacher personally to monitor the individual instruction of each pupil using conventional instructional materials.

Although the conception of an absolute orientation is admittedly old, operational implementation of the conception has yet to be attained. We have found that a radical readjustment in thinking is involved in shifting from one context to another. For example, consider the matter of "teaching the test." In a relative context, this is anathema; and rightly so, given the strategy used in constructing the test and the inferences to be derived from the test results. In an absolute context, on the other had, instruction is specifically directed toward teaching the test. However, concomitant changes in test construction and interpretation strategy provide such completely different referents that "teaching the test" is now a justifiable goal.

One of the objectives of the present research was to develop the necessary behavioral analyses, psychometric measures, and programmed instructional sequences required to implement an absolute orientation in the classroom for the three subject matter areas under investigation. We had optimistically hoped the research would demonstrate the ease with which an absolute approach could be effected. However, we seriously underestimated the power and complexity of the cumulative prior educational experiences of pupils and teachers alike. We are convinced now that these determinants, developed in a relative context, preclude the possibility of any programmed text (or any other currently available instructional technique, for that matter) being absolutely successful in the typical classroom under typical conditions irrespective of the adequacy of the behavioral analysis upon which the instruction is based or the technical sophistication of instructional sequencing. The present results strongly suggest that the contingencies operating in the typical classroom will simply not permit the program to function as intended.

For example, inspection of the program protocols of individual pupils from the final experiments indicates that the program never had a chance. Many pupils "never got on the program" in that they failed to achieve adequate performance on the first item form and on all subsequent measures thereafter. These pupils were obviously "having a ball." Conversations with the teachers indicated that they were just "that kind of pupil." Yet this behavior was at least tolerated by the teacher and the pupils experienced no aversive consequences.

Of course, most pupils did "play the game," at least some of the time. But what happended when a child failed to master an item form? The show simply continued. Some pupils managed to catch up later; many others obviously didn't. Bypassing functioned in about the same fashion. Since the teachers did not systematically reinforce good and poor performance differentially, the consequences of both desirable and undesirable responses were neutral, unless differentailly established by the pupil himself.

"Cheating" on the pretreated chemical responses was an interesting phenomenon. When not certain of an answer, many pupils took the easy way out by making a slight dot and going on to fill it in completely only if it proved to be the right color. Although these dots are easily detected, some teachers refused to entertain the possibility that the pupils were engaging in deception, either of themselves or of the teacher. In these classes cheating continued.

Absences and extracurricular interruptions played havoc with the programmed instruction, irrespective of the pacing mode. The difficulty was not so much one of instructing as of monitoring. Even when the pupils were present, "missing data" was rampant in some classes. Although a few of the missing exercises are attributable to logistic slippage between pupil and teacher or teacher and experimenter, it is obvious that many pupils simply failed to respond to the assignment as intended.

Altogether, it was "school as usual." The program never had a chance in competition for many aspects of the pupil's behavior.

One can easily find a scapegoat for the obtained results. Poor programs, one might conclude. Possibly. But our experiences with "the best" of commercial programs has been no different. Poor teachers, then? Not at all. We received excellent cooperation from the teachers participating in the experiments. We would anticipate exactly the same sort of results from any new group of competent teachers, and much poorer results from a group of even slightly less competent teachers. The program failed to achieve success in spite of the best efforts of the teachers involved.

Finally, one could simply give up, conclude that "programmed instruction is no damned good; it's a sink hole," and hurry back to the laboratory to pursue a "basic" research program, start pounding the drums for the next "new and revolutionary idea," or join a philosophical movement to protect the human dignity of pupils and teachers alike from control by machines and/or psychologists.

Unfortunately, these possible courses of action serve only to escape the situation rather than to ameliorate it. For those investigators who do continue to pursue the implementation of a criterion referenced approach, we should like to point to the prospect of a quick breakthrough just around the corner of the next punch card. However, we can't. We foresee no immediate possibility for dramatic improvement in formal education either with or without programmed instruction. Researchers seeking immediate spectacular results are likely to be disappointed.

Moreover, our research experience has led us to question the external validity of much of the corpus of currently available self-instructional research. Manipulations of such variables as response mode, stimulus presentation techniques, step size, etc., are indeed of interest. But so long as the investigations are conducted without adequate controls of classroom contingencies which likely account for far greater variance than the main effects being investigated, the results can have little practical value. The most likely outcome of such experimentation is n.s.d. The few statistically significant differences that are isolated stand little chance of being generalizable to other situation.

The Future

The foregoing comments have deliberately emphasized the negative side of the coin to counteract the naive but prevalent attitude that the technology ofprogrammed instruction is already sufficiently well developed to eliminate the major deficiencies of classroom instruction. Although we have found programmed instruction much less glamorous and much more frustrating than many enthusiasts have described it, we are firmly convinced that the objectives of the "new technology of education" are sound and that they will eventually be realized.

We remain highly optimistic concerning the long range possibilities for researchers who choose to invest their efforts in programmed instruction. It appears to us that two related but distinguishable research areas deserve immediate attention. First, in retrospect, it appears that our concern for external validity in the present research may have been misdirected. To maximize the external validity of the results, we took special pains not to sensitize the participating teachers prior to an experiment. Although the teachers were given complete and detailed information concerning the mechanics of the experimentation, they were deliberately kep naive with respect to the detailed objectives of the research. This was not difficult since the sheer mechanics of the instruction proved sufficiently complicated to keep the teachers occupied with the task without further consideration. We are well satisfied with the external validity of the results for the typical classroom.

However, we are somewhat less than satisfied with the typical classroom. It appears that a readjustment of the conception of the teacher's role in the research is now required. Just as we tried to go "all out" in teaching the test to the pupils, we must go "all out" to teach the teacher to teach the test. Unless the teacher has a criterion referenced orientation and is willing to shift her instructional operation to pay the price of the shift, there is little chance of making any great headway. The teachers in our research were, quite naturally, thinking as typical teachers. Their reinforcement in the research on the whole came not from effecting learning but from various secondary reinforcers associated with the experimentation. They were doing exactly what we asked of them, but in a sense we were asking them to do the wrong thing. The differing emphases made for difficulty.

Consider the "trivial" effects of a keying error in pre-treating a chemical answer space. In a textbook or standardized test, a keying error can go undetected for several years by pupils and teachers alike. However, under conditions of immediate feedback, a keying error is identified immediately and can easily play havoc with smooth ongoing classroom behavior. If the teacher treats the error as "typographical" and points it out early to all the pupils, no harm is done. However, unless the situation is handled carefully, the pupils can quickly lose confidence in the materials, the teacher, or the subject matter content. Thus, it is no surprise that the success of self instructional materials has been shown to be related to the teacher's general expectation of the adequacy of the materials (Schramm, 1964).

It is in one sense a source of amazement that programmed instruction researchers have so completely overlooked the dominant position of the teacher in the classroom. It is unreasonable (in retrospect) to assume that programmed materials will function independently of the teacher, so long as the teacher remains in total control of the classroom reinforcement system. However, the complexity of simply preparing adequate programmed materials has more than occupied the attention of researchers. What appears to be required now is the same careful attention to programing the classroom behavior of teachers as has been devoted to programing the behavior of pupils. This task is likely to prove at least as complicated as programing the behavior of pupils. But progress in the two areas is likely to be achieved concurrently.

Another research route deserves equal consideration. We have found that even the best teacher finds it humanly impossible to "keep up" with a classroom of pupils, when each child is continuously achieving. Even the evaluation procedures, to say nothing of the instructional aspects of the situation, become far too complicated for any one human being to handle. Machine usage appears inevitable. But let us hasten to emphasize that what is required is far more complicated than the already archaic "roll of paper in a box" gadgets presently glutting the market. A computer type system is clearly in order. Currently available computers are more than adequate to provide the storage, selection, and presentation capacities required to initiate this research. As the research progresses, the findings will undoubtedly lead to specifications for special purpose machines that are both more economical and more efficient than the general purpose computers now in use.

Again, previous efforts to capitalize upon machines have been handicapped by the imprecise behavioral analyses and instructional sequences heretofore available. Application of the item form concept is ideally suited to computerized instruction. Although great effort is required, it is a straightforward task to develop a sequence of instructional cues and a large pool of test items to be used for quality control as instruction proceeds. These can be stored in the computer for presentation to the pupil in an optimal sequence.

One of the chief advantages of the computer in instruction is its potential monitoring capacity. Information concerning pupil progress can be synthesized for reporting to the teacher. More importantly, pupils who are not performing as desired can be identified readily. The teacher is thus permitted to direct the instruction in an efficient manner, making full use of her instructional competence. Although the concept of computerized instruction is again not novel, the means of putting the concept into operation appear to be now at hand.

Research in programmed instruction has come a long way during the period covered by the present research project. The areas of teacher programing and computerized programing are both far removed from the classical conceptions of "linear" programs and "intrinsic" programs that dominated the thinking of self-instructional researchers at the time the project was initiated. But many further successive approximations will be required to realize the goal of "a new educational technology." At the present time, the promise lies not in any already developed product but in the pursuit of this goal.

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APPENDIX A

Fraction Readiness Test

1) 5 x 3	2) $16\overline{)28}$	3) How many times does 7 go into 21?	4) 2 + 8 + 9 =
5) 7 x 8 =	6) 16 ÷ 4 =	7) 21 + 7	8) 8 - 5
9) Subtract 5 from 10	10) 5 + 6	11) 4 x 3 =	12) 23 - 12 =
13) $8\overline{)28}$	14) 7 x 6	15) 18 - 5	16) How much is 4 plus 3?
17) 9 x 5	18) 16 - 9	19) $5\overline{)22}$	20) Divide 8 by 2.
21) 2 + 1 + 2 =	22) Multiply two times eight.	23) Add seven and one.	24) 50 ÷ 10 =
25) 2 x 2 =	26) 9 minus 3 equals	27) $12\overline{)23}$	28) 18 - 13
29) 6 + 9	30) 8 + 3	31) 8 x 9	32) Add three and four and one.
33) 3 + 8 + 7 =	34) How much is 12 take away 7?	35) 5 9 + 4	36) 6 x 4 =
37) How much is 9 times 3?	38) 14 - 5	39) 35 + 2	40) How many 6's are there in 30?
41) $3\overline{)15}$	42) 12 - 9		

APPENDIX B

Adding and Subtracting Like Fractions
Criterion Test - Form B

1) Is 23 a fraction or a whole number?

2) Which number in $\frac{2}{3}$ is the denominator?

3) What is the name of the top number in a fraction?

4) Look at the denominators. Which one is smallest?

$\frac{7}{9}$ $\frac{2}{5}$ $\frac{3}{4}$ $\frac{1}{12}$

5) Write a proper fraction using a 3 and a 10.

6) What kind of fraction = less than 1?

7) What kind of fraction = 1?

8) What kind of number has two parts, a whole number and a fraction?

9) Which one of these is a mixed number?

$\frac{66}{7}$ 667 $6\frac{6}{7}$ $\frac{7}{66}$

10) Which number of a fraction tells what kind?

11) In the fraction $\frac{3}{4}$, the 3 and the 4 are the (______) of the fraction.

12) When you add fractions, add the (________________) but not the (________________).

13) How much is $\frac{1}{3}$ and $\frac{1}{3}$?

14) Take $\frac{1}{5}$ away from $\frac{2}{5}$.

15) Add:

$$\begin{array}{r} 4 \\ +\ 3\frac{1}{3} \\ \hline \end{array}$$

16) Subtract:

$$\begin{array}{r} 4\frac{5}{6} \\ -\ 2 \\ \hline \end{array}$$

17) Subtract:

$$\begin{array}{r} \frac{2}{3} \\ -\ \frac{2}{3} \\ \hline \end{array}$$

18) Change $\frac{3}{4}$ to twelfths ($\frac{1}{12}$'s):

19) How many eighths ($\frac{1}{8}$'s) are there in $\frac{1}{4}$?

20) Which is smaller, $\frac{3}{4}$ or $\frac{5}{8}$?

21) Tell how to change a whole number to a fraction:

22) How many fourths ($\frac{1}{4}$'s) are there in 3?

23) $4 = \frac{?}{5}$

24) Tell how to change a mixed number to a fraction.

25) $3\frac{1}{3} = \frac{?}{3}$

26) How many fifths ($\frac{1}{5}$'s) are there in $2\frac{3}{5}$?

27) Subtract:

$$\begin{array}{r} 1\frac{1}{3} \\ -\ \frac{2}{3} \\ \hline \end{array}$$

28) Tell how to change an improper fraction to a whole number:

29) $\frac{12}{3} = ?$

30) $\frac{1}{3} + \frac{2}{3} =$

31) Add:

$$\begin{array}{r} \frac{3}{7} \\ +\ \frac{4}{7} \\ \hline \end{array}$$

32) Add:

$$\begin{array}{r} \frac{4}{5} \\ \frac{3}{5} \\ +\ \frac{3}{5} \\ \hline \end{array}$$

33) Tell how to reduce a fraction to lower terms:

34) Reduce to lower terms: $\frac{2}{4}$

35) Reduce to lower terms: $\frac{4}{8}$

36) Add:

$$\begin{array}{r} \frac{5}{14} \\ +\ \frac{2}{14} \\ \hline \end{array}$$

37) Subtract:

$$\begin{array}{r} \frac{9}{16} \\ -\ \frac{7}{16} \\ \hline \end{array}$$

38) Reduce: $\frac{4}{10}$

39) Reduce: $\frac{10}{16}$

40) Tell how to reduce a fraction to lowest terms:

---

41) Reduce to lowest terms:

$\frac{4}{8}$

---

42) Reduce to lowest terms:

$\frac{12}{18}$

---

43) Add:

$\frac{1}{12}$

$+ \frac{7}{12}$

---

44) Subtract:

$\frac{13}{16}$

$- \frac{1}{16}$

---

45) Tell how to change an improper fraction to a mixed number:

---

46) Add:

$\frac{3}{5}$

$+ \frac{3}{5}$

---

47) Add:

$\frac{3}{8}$

$+ \frac{7}{8}$

---

48) Add:

$\frac{7}{8}$

$+ \frac{5}{8}$

---

49)

$\frac{3}{8} + \frac{4}{8} + \frac{7}{8} =$

---

50) $\frac{13}{4} = ?$

APPENDIX C

Capitalization Review Sheet - Unit 18

In the sentences below, circle all the mistakes in capitalization you can find.

1. George Washington fought in the Revolutionary war.
2. We are going to celebrate my Birthday at Encanto park.
3. St. Paul's church is larger than our church.
4. the first day of the week is sunday, not monday.
5. Our teacher read The Adventures of tom Sawyer to us before easter vacation.
6. Most Spanish people like to Eat mexican food.
7. arthur stephens, junior, is the Son of mr. and mrs. arthur stephens, senior.
8. The New York Times is larger than our hometown newspaper.
9. Dad met general Anderson last february in Dallas, texas.
10. We went through the Panama canal when we sailed from the Pacific ocean to the atlantic.
11. July is usually the hottest month of the Summer, and august is usually hot, too.
12. San francisco is not as large as Los angeles.
13. The President of our Country is john f. kennedy.
14. The Country North of us is canada.
15. Our School begins the day after Labor day.
16. Another name for Independence Day is the Fourth of July.
17. The oldest military post in Minnesota is Fort Snelling.
18. "We can't come," said Kurt, "Because we have school that day."
19.

2626 west Spring Street
Phoenix 21, arizona

Dear grandma,

I am glad you're coming to visit us. Billy and I are going to the Airport to meet you when you come.

your grandson,

tommy

APPENDIX D

Capitalization and Punctuation Readiness Test

Part I

Directions: Each of the sentences below can be completed by one of the four choices given. Read the beginning part of each sentence. Look carefully at the underlined word. Then choose the word which completes the sentence best. Make a cross in the circle in front of the word you have chosen, like this ⊗. Study the sample below and notice how it has been marked.

Sample: A doll is a . . ○ book ⊗ toy ○ pupil ○ face

1. Rodeo is a kind of ○ contest ○ puzzle ○ animal ○ city

(The remaining items follow the form of item 1.)

2. Wishbones are found in: turkeys - shows - kites - carrots
3. Telephones are used to carry: books - pictures - sounds - smells
4. Emerald is a: stone - book - roof - tire
5. Atlantic is an: orange - organ - owl - ocean
6. Canoe is a kind of: fish - boat - wood - game
7. Cameras are used to take: clothes - pictures - friends - food
8. Navigators: starve - march - mail - sail
9. Calendars show: stars - shoes - news - days
10. *Adventures are: exciting - pretty - wet - dying*
11. Illustrate means: lose - make - use - show
12. Drought means: soft - sweet - dry - drum
13. Protestant is a: rich man - religion - river - ribbon
14. Deliver means: forget - toss - bring - never
15. Carnation is a: door - flower - office - lamp
16. Division is a: city - mountain - part - soldier
17. Peacock is a: vegetable - bird - man - salt
18. Glossy means: sharp - heavy - shiny - thin
19. Bracelets are things to: read - fry - wear - color
20. Puritans are: holidays - people - chickens - leaves
21. Screeches are: lessons - knives - songs - noises
22. Restaurants are places to: eat - study - read - sleep
23. Violets are: autos - flowers - rugs - ships
24. Tourists are: visitors - roads - papers - lions

Part II

Directions: Read each question carefully, then answer the items by making a cross, x , in the circle under the yes or the no. There are ten items for each question.

Is each of the following a country?

	Yes	No
1. Canada	○	○

(The remaining items follow the form of item 1.)

2. Coast
3. Mountains
4. Brazil
5. China
6. Seaport
7. Russia
8. Capital
9. Flight
10. Mexico

Is each of the following a city?

1. Town
2. Chicago
3. Phoenix
4. Suburb
5. Kansas City
6. World
7. Los Angeles
8. Village
9. State
10. Dallas

Is each of the following an abbreviation?

1. Co.
2. At.
3. By.
4. Mr.
5. Ave.
6. Out.
7. Up.
8. Doz.
9. Mon.
10. To.

Is each of the following a name?

1. Chicago Cubs
2. Club
3. Sears and Roebuck
4. School
5. Drugstore
6. Phoenix Republic
7. League
8. Arizona State
9. Lynda B. Johnson
10. Company

Is each of the following a month?

1. March
2. Summer
3. Daily
4. April
5. December
6. Coldest
7. Winter
8. July
9. Weekly
10. August

Is each of the following a day of the week?

1. Tomorrow
2. Tuesday
3. Friday
4. Yesterday
5. Holiday
6. Monday
7. Weekend
8. Saturday
9. Evening
10. Sunday

APPENDIX E

Fractions Review - Unit 27

1. How do you reduce a fraction to lowest terms?
2. How do you reduce a fraction to lower terms?
3. What is the name of the bottom number in a fraction?
4. How do you change a mixed number to an improper fraction?
5. Which is larger: $\frac{3}{5}$ $\frac{7}{10}$

6. $\frac{2}{4}$
$+ \frac{2}{4}$

7. $\frac{2}{9}$
$- \frac{2}{9}$

8. $\frac{1}{6}$
$+ \frac{5}{6}$

9. 4
$+ 3\frac{6}{7}$

10. $\frac{1}{7}$
$+ \frac{6}{7}$

11. $\frac{10}{16} =$

12. $\frac{7}{8}$
$+ \frac{1}{8}$

13. $\frac{5}{7}$
$+ \frac{2}{7}$

14. $\frac{9}{16}$
$- \frac{3}{16}$

15. $\frac{3}{7}$
$+ \frac{4}{7}$

16. $\frac{12}{16} =$

17. $\frac{3}{8}$
$+ \frac{5}{8}$

18. $\frac{4}{10}$
$\frac{8}{10}$
$+ \frac{8}{10}$

19. $\frac{1}{6}$
$+ \frac{2}{6}$

20. $\frac{3}{4}$
$\frac{3}{4}$
$+ \frac{2}{4}$

21. $\frac{6}{8}$
$+ \frac{2}{8}$

22. $\frac{6}{9} =$

23. $\frac{1}{10}$
$+ \frac{9}{10}$

24. $\frac{14}{2} =$

25. $\frac{3}{10}$
$+ \frac{7}{10}$

26. $\frac{1}{12}$
$+ \frac{7}{12}$

27. $\frac{3}{9}$
$+ \frac{6}{9}$

28. $\frac{8}{18} =$

29. $3\frac{3}{4} =$

30. $\frac{4}{8}$
$+ \frac{4}{8}$

Appendix F

Formulas for Preparation of Mimeograph Ink to Provide Immediate Knowledge of Results

The following formulas were developed by the Government Printing Office and reported by the Response Research Branch, U. S. Bureau of the Census (1962).

Black Mimeograph Ink for Printing Incorrect Answers

	%
Castor Oil	85.00
Carbon Black No. 1	3.75
Lampblack	2.50
Red Dye, C. I. 18050, C. I. Acid Red 1	8.75
	100%

Black Mimeograph Ink for Printing Correct Answers

	%
Castor Oil	88.75
Carbon Black No. 1	3.75
Lampblack	3.75
Yellow Dye, C. I. 19140, C. I. Acid Yellow 23	3.75
	100%

Special Writing and Developing Fluid

	%
Distilled Water	98.60
Blue Dye, C. I. 74180, C. I. Direct Blue 86	0.40
Wetting Agent Solution*	1.00
	100%

* Above wetting agent solution is prepared as follows:

	%
Tergitol Wetting Agent No. 7 Conc.	0.40
Distilled Water	99.60
	100%

Our experience indicated that the formulas could tolerate considerable "error of measurement" in preparation and still perform quite adequately. However, we did find it necessary to use considerably more dye than prescribed by the GPO formulas.

We tried initially to short circuit the problem of mixing the basic ink by simply adding the dye to commercial mimeograph ink. This did not work since commercial inks use linseed oil rather than castor oil. The linseed oil apparently holds the dye in permanent suspension and prevents its reaction with the water in the writing fluid.

We obtained better performance from the yellow than the red dye. Not only is the red dye more expensive, but much more appears to be required. Since the color selection by GPO was arbitrary, experimentation with other colors is suggested.

The lampblack and castor oil are generally available through any chemical supply company. We found the highest density castor oil to produce the best results. Use of Tergitol as a wetting agent is not critical; other wetting agents will perform adequately.

We obtained the other dyes through the National Aniline Division of Allied Chemical. These are described as follows:

Red = Fast Crimson GR, DI 18050
Yellow = Tartrazene, DI 19140
Blue = Solantine Turquoise
Black = Carbon Black

We encountered a problem in using the inks in that the formulas are apparently designed for a fluid ink mimeograph machine. The machine available to us uses a paste ink. To thicken the ink to a paste equivalent we used Cellosize Hydroxyethyl Cellulose WP-4400, obtainable from Union Carbide Chemicals. The choice of Cellosize was rather arbitrary, but it appeared to solve the problem quite adequately.

APPENDIX G

Capitalization Test

Form C (464)

Look at the sentences below. There are several words in each sentence that have two letters at the beginning. The top letter is a capital letter and the bottom letter is small. Look at each of these words. If you think that the word should begin with a capital letter, draw a circle around the capital letter. If you think it should begin with a small letter, draw a circle around the small letter. Here is an example:

a) My father's name is $\overset{\text{Ⓙ}}{\text{j}}$ohn $\overset{\text{Ⓙ}}{\text{j}}$ones.

The words John and Jones should start with a capital letter, so drawing circles around the capital letters would be right.

b) $\overset{\text{Ⓡ}}{\text{r}}$uth went $\overset{\text{H}}{\text{ⓗ}}$ome.

A circle is drawn around the capital letter R for Ruth. This is right. A circle is drawn around the small letter for the word home. This is right because it should not start with a capital letter.

Now turn the page and begin with number 1. Look at the word and decide if it should begin with a capital or small letter. Then draw a circle around the right letter.

(Page 2)

1. My $\overset{\text{K}}{\text{k}}$itten tries to follow $\overset{\text{M}}{\text{m}}$e when $\overset{\text{I}}{\text{i}}$ go upstairs, $\overset{\text{B}}{\text{b}}$ut $\overset{\text{S}}{\text{s}}$he can't climb the steps yet.

(The remaining items follow the form of item 1. Underlined letters represent points of decision. Upper case letters were always printed above, and lower case below, the line.)

2. In some years $\underline{\text{E}}$aster comes late in $\underline{\text{M}}$arch, and at other $\underline{\text{t}}$imes it falls on a $\underline{\text{S}}$unday in early $\underline{\text{A}}$pril.
3. If you sailed straight $\underline{\text{s}}$outh from $\underline{\text{E}}$ngland, you would soon reach the $\underline{\text{c}}$oast of $\underline{\text{F}}$rance.
4. After Judy's $\underline{\text{f}}$ather sold his $\underline{\text{s}}$tore, $\underline{\text{t}}$hey moved to $\underline{\text{F}}$lorida and bought a house in $\underline{\text{M}}$iami.
5. It is usually very hot in $\underline{\text{J}}$uly, $\underline{\text{b}}$ut this $\underline{\text{y}}$ear there was a lot of rain and $\underline{\text{i}}$t was cooler.
6. Let me take my temperature; $\underline{\text{t}}$hen $\underline{\text{I}}$'ll know whether $\underline{\text{I}}$'m $\underline{\text{i}}$ll or not.
7. My little $\underline{\text{r}}$abbit is named $\underline{\text{H}}$oppy. $\underline{\text{H}}$e likes to eat carrot tops and $\underline{\text{c}}$abbage leaves.

8. There is a girl named Tina in the fourth grade who came from the Philippine Islands.
9. Donna and I tried to pet the little lambs, but they were afraid of us and ran away.
10. The Rio Grande separates Texas and Mexico. This river is almost 1800 miles long.
11. We spent a whole month at the seashore. We could see the Atlantic Ocean from our front porch.
12. When the new kittens are born, Mother says I'll be able to choose one for a pet.
13. I walked to school every day, even in winter, when we lived on Clinton Street.
14. When a tornado hit my home town, many houses and buildings were destroyed.
15. We brought ads from newspapers to class today. I had a funny one from the "Maplewood Journal."
16. Wouldn't it be nice if holidays always came on Mondays? Then we would always have a long weekend.
17. We always spend Thanksgiving at Grandmother's house. We have turkey and pumpkin pie.
18. We learned two new songs this week. One is called "Dinah" and the other "The Echo Song."
19. "Tomorrow," said our music teacher, "I will teach you a little French song."
20. He reported on a story about the great northern wilderness, "Yukon Bill."
21. Douglas has a job with Mr. Nelson, the grocer, after school every day.
22. On Mother's Day, Rita and I gave our mother some perfume. We bought it with our own money.
23. This book about King Arthur and his knights has many exciting stories in it.
24. I can remember the first movie that I ever saw. It was a cartoon about Donald Duck.
25. There was a bees' nest in the hollow apple tree in our back yard last year.
26. In Farmer Graham's cornfield there were hundreds of golden pumpkins, enough for everyone in the county.
27. "Don't be late for supper," Mother warned. "We are having ice cream for dessert."
28. This is a unit on animal stories like "Bambi" and "Smoky."
29. The name of the story that I liked best of all was "The House on Turkey Ridge."

30. The Puritans could not have lived through their first winter without the help of the Indians.

31. The city of San Francisco is famous for its steep hills and the district called Chinatown.

32. These pictures of Kentucky and North Carolina came from the magazine Holiday.

33. The South depends on its tobacco crop, and southern farmers are losing money.

34. Of the six New England states, Maine is the one that lies farthest north.

35. Before the graduation program began, the audience stood and sang "America the Beautiful."

36. When we drove to California last year, we stopped off at Salt Lake City and spent several days there.

37. In the early spring the Eskimo tribe moved out of the igloos into tents made from reindeer skins.

38. The story of the climb to the top of Mount Everest is told in the book The Conquest of Everest.

39. Most people take their vacations during the summer months, but I prefer to have mine after Labor Day.

40. Instead of just one moon, like that of the earth, the planet Jupiter has several moons.

41. A turn to the left here means I'll be going south, and he lives to the north.

42. Chickens, geese, and turkeys are sent to large cities before all of the important holidays.

43. When Barbara was six years old, her parents moved from Chicago to a small town in the South.

44. My grandfather, who is a preacher, always reads several verses from the Bible before he begins a meal.

45. We enjoyed the visit very much, and we learned many facts about the printing of a daily newspaper.

46. The Mississippi River rises in northern Minnesota and empties finally into the Gulf of Mexico.

47. The minister, Dr. Simpson, often plays ball with the boys of his church.

48. They decided to take a long ride that Sunday and to have dinner at a restaurant in the next town.

49. The next meeting of the stamp club will be held on the first Tuesday after Easter vacation.

50. Warren sent us a picture post card of the Washington Monument. His grandmother took him to see it.

51. The salesman treated us just like important customers. He bowed and said, "May I help you, please?"

52. The plaid skirt that Grandmother bought for me as a birthday present came from Scotland.

53. After seeing the movie "Riders of the Sage," Roger decided he wanted to join the Texas Rangers.

54. Go north three miles, then east two miles. You will end up on a hill overlooking the north part of town.

55. When Bobby took a trip through the Southwest, he brought back a small wool Navajo rug.

56. In the next election, Governor Smith probably will be the Democratic candidate for the Senate.

57. The Call of the Wild was one of Dad's favorite stories when he was in high school.

58. "The new cadillac," said the automobile salesman, "is the finest car on the road."

59. This story describes an Indian attack on Fort Gibson in the days when the West was being settled.

60. "Come," she replied. "Many people will be at the party I'm giving."

61. If you like adventure stories, you should read this autobiography called My Five Years in the Congo.

62. She asked, "Is your house north of here, or west of here? It appears that I'm lost."

63. The barber put the cloth over my shoulders and said, "A shave today, sir, or just a haircut?"

64. The Hudson River was explored in the year 1609 by the Englishman, Captain Henry Hudson.

65. In 1954 Congress changed the name of Armistice Day to the name Veteran's Day.

APPENDIX H

Sample Capitalization Unit
Unit 4

Pretest

1. The $\begin{smallmatrix}\bigcirc\\ W\\ w\\ \bigcirc\end{smallmatrix}$eekly spelling test will be given either $\begin{smallmatrix}\bigcirc\\ T\\ t\\ \bigcirc\end{smallmatrix}$omorrow or $\begin{smallmatrix}\bigcirc\\ W\\ w\\ \bigcirc\end{smallmatrix}$ednesday.

(The remaining items follow the form of item 1. Underlined letters represent points of decision. Upper case letters were always printed above, and lower case below, the line.)

2. Which is the $\underline{f}$irst $\underline{d}$ay of the $\underline{w}$eek?
3. On $\underline{S}$aturdays we have $\underline{l}$unch in the $\underline{a}$fternoon.
4. The first $\underline{w}$eek is a $\underline{h}$oliday $\underline{w}$eek.
5. Is $\underline{W}$ednesday a $\underline{v}$acation $\underline{d}$ay?
6. There are seven $\underline{d}$ays in a $\underline{w}$eek and 52 $\underline{w}$eeks in a $\underline{y}$ear.
7. The $\underline{f}$irst $\underline{s}$pring month is $\underline{M}$arch.
8. My $\underline{a}$nniversary is in $\underline{A}$pril.
9. This $\underline{y}$ear the $\underline{l}$ast $\underline{d}$ay of $\underline{S}$ept. is a $\underline{S}$unday.
10. Every $\underline{J}$une we start $\underline{t}$hree $\underline{m}$onths' $\underline{v}$acation.
11. This $\underline{y}$ear's $\underline{f}$ootball $\underline{s}$eason begins $\underline{F}$ri. $\underline{n}$ight.

Go to the next page.

Skip ahead to Green Test #4B.

****** ****** ******

Programmed Text

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1. $\underline{\text{Always}}$ capitalize the $\underline{\text{name}}$ of a day or month.
Never capitalize the $\underline{\text{kind}}$ of a day or month.

We go to church on $\begin{smallmatrix}S^{*}\\ s\end{smallmatrix}$unday.

We stay inside on a $\begin{smallmatrix}R\\ r\end{smallmatrix}$ainy day.

---

* Response choices were chemically treated in the program to provide S with immediate knowledge of results.

2. Which are the names of the days of the week?

SATURDAY WEDNESDAY YESTERDAY
SCHOOL DAY TOMORROW FRIDAY

3. The 7 days and the 12 months are names. Words like every day, last month, this year, are kinds.

Tell whether these words are names or kinds.

	Name	Kind
SUNDAY		
TONIGHT		
NOVEMBER		
RECESS		

4. Tell whether these words are names or kinds.

	Name	Kind
VACATION		
WEEKLY		
THURSDAY		
BEDTIME		
SUMMER SCHOOL		
APRIL		

5. Tell whether these words are names or kinds.

	Name	Kind
WEEK		
JUNE		
FEBRUARY		
NIGHT		
TUESDAY		
NOONTIME		

6. Which should be capitalized?

name of month name of day kind of month
kind of day kind of week kind of year

7. Which should be capitalized?

EVERYDAY MONDAY SOMEDAY AFTERNOON

8. Which are names?

OCTOBER JUNE SATURDAY MIDNIGHT

9. Capitalize
kinds of days or months.
Do not capitalize

Capitalize
names of days or months.
Do not capitalize

10. Which is an abbreviation?

AUG. MAY

11. Capitalize abbreviations of names just as you do the whole word.

$^{W}_{w}$eek $^{W}_{w}$k. $^{D}_{d}$ec. $^{D}_{d}$ecember

12. Which should be capitalized?

MONTH SUNDAY YR. MO. TUES. YEARLY

13. Which are names?

MINUTE FEBRUARY HR. MIN. NOV. THURS.

14. The seasons of the year are not capitalized. Which are seasons?

YEAR AUTUMN FALL WINTER SPRING SUMMER

15. $^{V}_{v}$acation $^{S}_{s}$ummer $^{S}_{s}$emester $^{S}_{s}$pring

---

16. $^{W}_{w}$eekend $^{M}_{m}$o. $^{T}_{t}$ues. $^{A}_{a}$utumn

---

17. Capitalize
seasons.
Do not capitalize

18. Capitalize
abbreviations of seasons
Do not capitalize

19. Capitalize
kinds of days.
Do not capitalize

Capitalize
abbreviations of names of months.
Do not capitalize

---

20. $^{T}_{t}$hursday $^{B}_{b}$reakfast $^{N}_{n}$oon $^{M}_{m}$orning $^{F}_{f}$ebruary $^{D}_{d}$aily

---

21. $^{H}_{h}$arvest $^{A}_{a}$pr. $^{S}_{s}$unday $^{D}_{d}$aytime

$^{D}_{d}$ay $^{A}_{a}$fter $^{T}_{t}$omorrow $^{W}_{w}$eek $^{D}_{d}$ays

---

22. $^{F}_{f}$ri. $^{D}_{d}$aytime $^{W}_{w}$eekend $^{N}_{n}$ovember

the $^{S}_{s}$ummer $^{M}_{m}$onth's a $^{M}_{m}$onth's $^{V}_{v}$acation

---

Posttest

○ ○ ○
1. Is $^{S}_{s}$aturday a $^{S}_{s}$chool $^{D}_{d}$ay?
○ ○ ○

(The remaining items follow the form of item 1. Underlined letters represent points of decision. Upper case letters were always printed above, and lower case below, the line.)

2. This year's baseball season begins Sat. afternoon.
3. Which is the last day of the week?
4. The monthly reading test will be given either tomorrow or Friday.
5. The first fall month is Sept.
6. My birthday is in January.
7. On Sundays we eat dinner at noon.
8. Every July we go on a two-weeks' vacation.
9. 1964 is a leap year.

10. There are twelve months in a year and 100 years in a century.
11. This year the first day of Oct. is a Monday.

Go back to Unit #4, Question #1.
Go to the White Test Book, #4.

****** ****** ******

Unit Test*

1. $^{C}_{c}$all your home!

(The remaining items follow the form of item 1. Underlined letters represent points of decision. Upper case letters were always printed above, and lower case below, the line.)

2. Go in the room.
3. the first Monday of June
4. When I leave
5. The clock struck one.
6. last Dec. 10
7. at school
8. Now I've found it.
9. You are late.
10. next Friday
11. December 20
12. Very well, he may go.
13. Wait! Who are you?
14. My watch is broken.
15. every Tuesday
16. Feb. 14
17. Hurry! I'll be late!
18. You're it.
19. late Saturday night
20. John Paul Jones
21. our dog
22. John Smith
23. January and February
24. every Wednesday
25. Fire is hot; ice is cold.
26. on Sunday
27. Our pet mouse
28. tell him
29. June 20,
30. Will you go? Please tell me.
31. In Sept. school begins.
32. his sister's alarm clock
33. Last July
34. Smokey, the Wonder Horse
35. I am tired. Please be quiet.
36. With my friends
37. When I go
38. The March wind is cold.
39. my mother's friend
40. on Thursday
41. Wait, you left your hat.
42. Doris L. Garrett
43. I lost it. Will you help me look?
44. Say that I'm sorry.
45. The hour is late.

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* This is the Review Exercise for Unit 4.

APPENDIX I

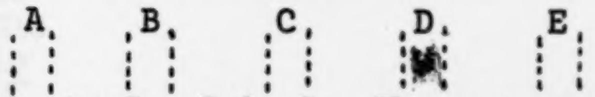
ADDING AND SUBTRACTING LIKE FRACTIONS

CRITERION TEST - FORM A (0164)

Please do not write on this booklet. Look at the sample question below:

3 + 3 = A. 3 B. 5 C. 9 D. 6 E. N.G.

There are five answer choices lettered A, B, C, D, and E. Now look at your answer sheet. For each question there are five answer choices that look like this:

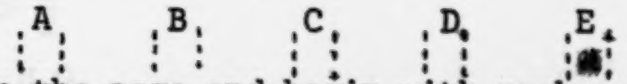


The answer to 3 + 3 is 6. The answer space lettered D on the answer sheet goes with the correct answer, 6; so you blacken in the space between the dotted lines for answer D, just like it is shown above.

Look at another sample question:

4 + 1 = A. 4 B. 3 C. 6 D. 2 E. N.G.

The answer is 5, but none of the lettered choices include the right answer. Letter E., N.G., means not given. Whenever you don't find the right answer given, blacken in the E. space for not given, as shown below:



Now turn the page and begin with number 1. Make sure the question number in the booklet goes with the question number on the answer sheet.

1) What kind of number is 23?
   - A. Roman number
   - B. fraction
   - C. whole number
   - D. mixed number
   - E. N.G. (not given)

2) What is the name of the top number in a fraction?
   - A. denominator
   - B. numerator
   - C. divisor
   - D. improper number
   - E. N.G.

3) What is the 3 in $\frac{4}{3}$?
   - A. numerator
   - B. whole number
   - C. divisor
   - D. improper number
   - E. N.G.

4) Which number in $\frac{2}{3}$ is the denominator?
   - A. $\frac{2}{3}$
   - B. 3
   - C. 23
   - D. 2
   - E. N.G.

5) Which number in $\frac{3}{2}$ is the denominator?
   - A. 23
   - B. 2
   - C. $\frac{2}{3}$
   - D. 3
   - E. N.G.

6) $\frac{7}{9}$ $\frac{2}{5}$ $\frac{3}{4}$ $\frac{1}{12}$

Look at the denominators. Which one is smallest?

A. 1
B. 4
C. 0
D. 2
E. N.G.

7) Which is a proper fraction?

A. $\frac{3}{10}$
B. 310
C. $\frac{10}{3}$
D. $3\frac{1}{10}$
E. N.G.

8) Which is an improper fraction?

A. $\frac{4}{5}$
B. 58
C. $\frac{5}{8}$
D. $5\frac{1}{8}$
E. N.G.

9) What kind of fraction = less than 1?

A. improper
B. mixed
C. whole
D. proper
E. N.G.

10) What kind of fraction = 1?

A. proper
B. mixed
C. improper
D. whole
E. N.G.

11) What kind of fraction = more than 1?

A. whole
B. part
C. mixed
D. proper
E. N.G.

12) Which is an improper fraction?

A. $\frac{1}{1}$
B. $\frac{1}{2}$
C. $\frac{1}{10}$
D. 1
E. N.G.

13) If a number has 2 parts, a whole number and a fraction, what kind of number is it?

A. proper
B. mixed
C. whole
D. improper
E. N.G.

14) Which of these is a mixed number?

A. $\frac{66}{7}$
B. 667
C. $\frac{6}{67}$
D. $6.67
E. N.G.

15) Which number of a fraction tells how many?

A. improper
B. denominator
C. numerator
D. proper
E. N.G.

16) When you add fractions, add the

- A. both the numerators and the denominators
- B. denominators but not the numerators
- C. neither the numerators nor the denominators
- D. numerators but not the denominators
- E. N.G.

17) How much is $\frac{1}{3}$ and $\frac{1}{3}$?

- A. $\frac{1}{6}$
- B. $\frac{1}{3}$
- C. $\frac{2}{6}$
- D. $\frac{2}{3}$
- E. N.G.

18)

$$\begin{array}{r} 4 \\ +\ 3\frac{1}{3} \\ \hline \end{array}$$

- A. $7\frac{2}{3}$
- B. $\frac{1}{3}$
- C. $7\frac{1}{3}$
- D. 7
- E. N.G.

19)

$$\begin{array}{r} \frac{4}{5} \\ -\ \frac{3}{5} \\ \hline \end{array}$$

- A. $\frac{1}{5}$
- B. $\frac{1}{0}$
- C. $\frac{1}{10}$
- D. $\frac{4}{10}$
- E. N.G.

20)

$$\begin{array}{r} 4\frac{5}{6} \\ -\ 2 \\ \hline \end{array}$$

- A. $2\frac{5}{6}$
- B. 2
- C. $\frac{5}{6}$
- D. $2\frac{1}{6}$
- E. N.G.

21)

$$\begin{array}{r} \frac{2}{3} \\ -\ \frac{2}{3} \\ \hline \end{array}$$

- A. $\frac{0}{3}$
- B. $\frac{0}{0}$
- C. $\frac{2}{0}$
- D. 0
- E. N.G.

22) $\frac{3}{5} = \frac{?}{10}$

- A. $\frac{6}{5}$
- B. $\frac{3}{10}$
- C. $\frac{5}{10}$
- D. $\frac{6}{10}$
- E. N.G.

23) The numerator and the denominator of a fraction are

- A. wholes
- B. parts
- C. terms
- D. fractions
- E. N.G.

24) Change $\frac{3}{4}$ to twelfths ($\frac{1}{12}$'s)

A. $1\frac{1}{12}$
B. $\frac{3}{12}$
C. $\frac{9}{12}$
D. $\frac{6}{12}$
E. N.G.

25) How many eighths ($\frac{1}{8}$'s) are there in $\frac{1}{4}$?

A. 2
B. 4
C. 8
D. 12
E. N.G.

26) In the fraction $\frac{3}{4}$, the 3 and the 4 are the

A. denominators of the fraction
B. terms of the fraction
C. parts of the fraction
D. numerators
E. N.G.

27) Which is largest?

A. $\frac{1}{2}$
B. $\frac{1}{8}$
C. $\frac{3}{8}$
D. $\frac{1}{4}$
E. $\frac{2}{8}$

28) Which is smallest?

A. $\frac{11}{15}$
B. $\frac{2}{3}$
C. $\frac{9}{12}$
D. $\frac{5}{6}$
E. $\frac{7}{9}$

29) How many fourths ($\frac{1}{4}$'s) are there in 3?

A. 8
B. 4
C. 12
D. 3
E. N.G.

30) To change a whole number to a fraction

A. divide the denominators and multiply by 2
B. divide the denominators and multiply by the numerator
C. divide the denominator by the numerator
D. divide the numerator by the demoninator
E. N.G.

31) $4 = \frac{?}{5}$

A. 5
B. 20
C. 15
D. 9
E. N.G.

32) To change a mixed number to a fraction

A. multiply the denominator x the whole number and add the numerator
B. multiply the whole number x the numerator and add the denominator
C. multiply the denominator x the numerator and add the whole number
D. multiply the numerator x the whole number and add the denominator
B. N.G.

33) $3\frac{1}{3} = \frac{?}{3}$

A. 10
B. 9
C. 7
D. 6
E. N.G.

34) How many fifths ($\frac{1}{5}$'s) are there in $2\frac{3}{5}$?

A. $\frac{17}{5}$
B. $\frac{12}{5}$
C. $\frac{10}{5}$
D. $\frac{13}{5}$
E. N.G.

35)

$$\begin{array}{r} 1\frac{1}{3} \\ -\ \frac{2}{3} \\ \hline \end{array}$$

A. $\frac{2}{3}$
B. $1\frac{1}{3}$
C. $\frac{1}{3}$
D. $1\frac{2}{3}$
E. N.G.

36) To change an improper fraction to a whole number

A. multiply the numerator x the denominator
B. divide the numerator by the denominator
C. multiply the denominator x the whole number
D. divide the whole number by the denominator
E. N.G.

37) $\frac{12}{3} =$

A. 36
B. $\frac{4}{1}$
C. 4
D. $\frac{1}{4}$
E. N.G.

38) $\frac{1}{3} + \frac{2}{3} =$

A. $\frac{3}{3}$
B. $\frac{3}{1}$
C. 3
D. 1
E. N.G.

39)

$$\begin{array}{r} \frac{3}{7} \\ +\ \frac{4}{7} \\ \hline \end{array}$$

A. 1
B. $\frac{7}{1}$
C. 7
D. $\frac{7}{7}$
E. N.G.

40)

$$\begin{array}{r} \frac{4}{5} \\ \frac{3}{5} \\ +\ \frac{3}{5} \\ \hline \end{array}$$

A. $\frac{10}{1}$
B. $\frac{10}{5}$
C. 2
D. 1
E. N.G.

41) Reduce $\frac{2}{4}$ to lowest terms

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. $\frac{2}{2}$

D. $\frac{2}{1}$

E. N.G.

42) Reduce $\frac{3}{12}$ to lowest terms

A. $\frac{1}{3}$

B. $\frac{4}{1}$

C. $\frac{4}{3}$

D. $\frac{1}{4}$

E. N.G.

43) Reduce $\frac{4}{10}$ to lowest terms

A. $\frac{1}{2}$

B. $\frac{2}{5}$

C. $\frac{2}{10}$

D. $\frac{1}{5}$

E. N.G.

44) To reduce a fraction to lowest terms

A. divide both terms by $\frac{1}{3}$ the numerator

B. divide both terms by the numerator

C. divide both terms by $\frac{1}{2}$ the numerator

D. divide both terms by the same number

E. N.G.

45) Reduce $\frac{10}{16}$ to lowest terms

A. $\frac{2}{8}$

B. $\frac{2}{3}$

C. $\frac{5}{16}$

D. $\frac{5}{8}$

E. N.G.

46) Reduce $\frac{4}{8}$ to lowest terms

A. $\frac{1}{4}$

B. $\frac{2}{4}$

C. $\frac{1}{2}$

D. $\frac{2}{8}$

E. N.G.

47) Reduce $\frac{12}{18}$ to lowest terms

A. $\frac{6}{9}$

B. $\frac{8}{12}$

C. $\frac{4}{6}$

D. $\frac{2}{3}$

E. N.G.

48) $\frac{24}{16}$ =

A. $1\frac{1}{2}$

B. $1\ \frac{8}{16}$

C. $1\frac{1}{8}$

D. $1\frac{4}{8}$

E. N.G.

49) To change an improper fraction to a mixed number

A. multiply the whole number by the denominator
B. divide the whole number by the denominator
C. divide the numerator by the denominator
D. multiply the whole number by the denominator and add the numerator
E. N.G.

50) $\frac{20}{12} =$

A. $1\frac{4}{6}$
B. $1\frac{8}{12}$
C. $1\frac{2}{3}$
D. $1\frac{2}{6}$
E. N.G.

51) $\frac{13}{4} =$

A. $4\frac{1}{3}$
B. $3\frac{1}{4}$
C. $1\frac{3}{4}$
D. $3\frac{5}{4}$
E. N.G.

52)
$$\begin{array}{r} \frac{5}{14} \\ +\ \frac{2}{14} \\ \hline \end{array}$$

A. $\frac{7}{14}$
B. $\frac{7}{7}$
C. $\frac{1}{14}$
D. $\frac{1}{2}$
E. N.G.

53)
$$\begin{array}{r} 1\frac{1}{4} \\ -\ \frac{3}{4} \\ \hline \end{array}$$

A. $1\frac{4}{4}$
B. $\frac{8}{4}$
C. $\frac{1}{4}$
D. $\frac{3}{4}$
E. N.G.

54)
$$\begin{array}{r} \frac{1}{12} \\ +\ \frac{7}{12} \\ \hline \end{array}$$

A. $\frac{2}{3}$
B. $\frac{8}{12}$
C. $\frac{4}{6}$
D. $\frac{3}{4}$
E. N.G.

55)
$$\begin{array}{r} \frac{9}{16} \\ -\ \frac{7}{16} \\ \hline \end{array}$$

A. $\frac{2}{8}$
B. $\frac{1}{4}$
C. $\frac{1}{8}$
D. $\frac{2}{16}$
E. N.G.

56) $$\begin{array}{r} \frac{13}{16} \\ -\ \frac{1}{16} \\ \hline \end{array}$$

A. $\frac{3}{4}$

B. $\frac{9}{12}$

C. $\frac{6}{8}$

D. $\frac{12}{4}$

E. N.G.

57) $$\begin{array}{r} \frac{3}{5} \\ +\ \frac{3}{5} \\ \hline \end{array}$$

A. $\frac{6}{5}$

B. $1\frac{5}{6}$

C. $1\frac{3}{5}$

D. $1\frac{1}{5}$

E. N.G.

58) $\frac{3}{8} + \frac{7}{8} =$

A. $\frac{5}{8}$

B. $1\frac{2}{8}$

C. $1\frac{1}{4}$

D. $1\frac{5}{4}$

E. N.G.

59) $$\begin{array}{r} \frac{7}{8} \\ +\ \frac{5}{8} \\ \hline \end{array}$$

A. $1\frac{1}{2}$

B. $1\frac{2}{8}$

C. $1\frac{2}{4}$

D. $1\frac{4}{8}$

E. N.G.

60) $\frac{3}{8} + \frac{4}{8} + \frac{7}{8} =$

A. $1\frac{6}{8}$

B. $1\frac{3}{8}$

C. $1\frac{6}{14}$

D. $1\frac{3}{4}$

E. N.G.

APPENDIX J

Sample Fraction Unit
Unit 23

Pretest*

1.	$\frac{4}{3} =$	$1\frac{1}{3}$	$1\frac{1}{4}$	7	$1\frac{3}{4}$	Not given
2.	$\frac{8}{5} =$	3	$1\frac{5}{8}$	$1\frac{5}{3}$	$1\frac{3}{8}$	Not given
3.	$\frac{15}{4} =$	$3\frac{4}{15}$	$3\frac{3}{4}$	$3\frac{4}{11}$	$3\frac{11}{15}$	Not given
4.	$\frac{15}{8} =$	$1\frac{7}{8}$	$1\frac{7}{15}$	$1\frac{8}{15}$	$1\frac{8}{7}$	Not given
5.	$\frac{9}{2} =$	$4\frac{2}{9}$	$1\frac{4}{9}$	$4\frac{2}{7}$	$4\frac{1}{2}$	Not given
6.	$\frac{10}{4} =$	$2\frac{2}{4}$	$2\frac{4}{10}$	$2\frac{2}{5}$	$2\frac{4}{6}$	Not given
7.	$\frac{14}{6} =$	$2\frac{1}{3}$	$2\frac{6}{14}$	$2\frac{2}{6}$	$2\frac{6}{8}$	Not given

How well did you do? (________) wrong.

If you had 0 or 1 wrong, go to TEST-23B in this book.
If you had 2 or more than 2 wrong, go back to Problem
#1049 in Book 6.

****** ****** ******

Programmed Text

(Note: Frames were presented in horizontal sequence in the experiment)

1048) Stop!

Place a book mark in this book.
Take TEST-22B in the Yellow Book.**

Answer 1047

$\frac{10}{15} = \frac{2}{3}$

$\frac{6}{16} = \frac{3}{8}$

$\frac{6}{9} = \frac{2}{3}$

---

* Directions for pupils to proceed to this test are found immediately following TEST-22B, which is the posttest for Unit 22. See Frame 1048, above.

** The Yellow Book is the book containing the unit pre- and posttests.

1049) Change $\frac{4}{2}$ to a whole number.

Have you finished your tests in the Yellow Book?

If you have, go on with #1049.

If you haven't go back to #1048.

1050) $\frac{4}{2} = 2$

What kind of fraction is $\frac{4}{2}$?

What kind of number is 2?

improper fraction

proper fraction

whole number

mixed number

Answer 1049

$\frac{4}{2} = 2$

1051) $\frac{4}{2} = 2$

To change an improper fraction to a whole number, divide / multiply the numerator by the denominator.

Answer 1050

improper fraction

whole number

1052) Which is a mixed number?

$2\frac{1}{2}$ $\frac{21}{2}$ 212

Answer 1051

divide

1053) Change $\frac{9}{3}$ to a whole number:

Answer 1052

$2\frac{1}{2}$

1054) $\frac{12}{3}$ is an improper fraction.

Change it to a whole number:

Answer 1053

$9 \div 3 = 3$

1055) $\frac{13}{3}$ is an improper fraction.

Can it be changed to a whole number with no remainder?

Answer 1054

$12 \div 3 = 4$

1056) $\frac{14}{3}$ is an improper fraction. It can't be changed to a whole number because it doesn't come out even. Which of these two improper fractions can be changed to a whole number? $\frac{15}{3}$ $\frac{16}{3}$	Answer 1055 No, because 13 ÷ 3 doesn't come out even. (or because there is a remainder.)
1057) If an improper fraction can't be changed to a whole number, you must change it to a mixed number. Which of these two improper fractions must be changed to a mixed number? $\frac{17}{3}$ $\frac{18}{3}$	Answer 1056 $\frac{15}{3}$
1058) $\frac{19}{3}$ can be changed to a mixed number but not to a whole number because the answer comes out even when you divide. ☐ there is a remainder when you divide. ☐	Answer 1057 $\frac{17}{3}$
1059) $\frac{5}{3}$ can be changed to a mixed number ☐ whole number ☐	Answer 1058 there is a remainder when you divide. ☑
1060) $\frac{5}{3}$ 5 ÷ 3 = 1 R2 There is a remainder of 2 when you divide 5 by 3. The remainder is the numerator of the fraction in the mixed number. $\frac{5}{3} = 1\frac{(\ )}{3}$	Answer 1059 mixed number ☑
1061) Change $\frac{7}{2}$ to a mixed number. 7 ÷ (__) = 3 R1 = (__ -)	Answer 1060 $1\frac{(2)}{3}$

1062) Change $\frac{9}{2}$ to a mixed number. 9 ÷ (__) = (__) R(__) = (____)	Answer 1061 7 ÷ (2) = (3) R(1) = ($3\frac{1}{2}$)
1063) When you change an improper fraction to a mixed number, the remainder is the whole number ☐ numerator ☐ denominator ☐	Answer 1062 9 ÷ (2) = (4) R(1) = ($4\frac{1}{2}$)
1064) Change $\frac{5}{2}$ to a mixed number. ( ) ÷ ( ) = 2 R1 = (____)	Answer 1063 numerator ☑
1065) If you change $\frac{7}{3}$ to a mixed number, what will the denominator of the fraction in the mixed number be? $2\frac{1}{3}$ $2\frac{1}{2}$	Answer 1064 (5) ÷ (2) = 2 R1 = ($2\frac{1}{2}$)
1066) $\frac{8}{3} = 2\frac{2}{3}$ The denominator in a mixed number must be the same as the denominator ☐ numerator ☐ of the improper fraction.	Answer 1065 $2\frac{1}{(3)}$
1067) What will the denominator be if you change $\frac{9}{2}$ to a mixed number? (____)	Answer 1066 denominator ☑
1068) Change $\frac{4}{3}$ to a mixed number.	Answer 1067 (2)
1069) If you change $\frac{6}{2}$, the answer will be a whole number ☐ mixed number ☐	Answer 1068 $1\frac{1}{3}$

1070) Change $\frac{7}{4}$ to a mixed number.

Answer 1069
whole number ☑

1071) To change an improper fraction to a mixed number,

multiply ☐ the numerator ☐ by the
divide ☐ denominator ☐

numerator. ☐
denominator. ☐

Answer 1070
$1\frac{3}{4}$

1072) Change $\frac{13}{5}$ to a mixed number.

Answer 1071
divide ☑
numerator ☑
denominator ☑

1073) Which can be changed to a whole number?

$\frac{6}{3}$ $\frac{6}{5}$

Answer 1072
$2\frac{3}{5}$

1074) Which can be changed to a mixed number?

$\frac{8}{4}$ $\frac{11}{4}$

Answer 1073
$(\frac{6}{3}) = 2$

1075) Change $\frac{18}{6}$:

Answer 1074
$(\frac{8}{4}) = 2$

1076) Change $\frac{11}{6}$:

Answer 1075
$\frac{18}{6} = 3$
(There is no remainder, so your answer is a whole number, not a mixed number.)

1077) To change an improper fraction to a whole number,

multiply the numerator by the numerator.
divide denominator denominator.

Answer 1076
$\frac{11}{6} = 1\frac{5}{6}$

1078) Change $\frac{9}{5}$:	Answer 1077 divide numerator denominator
1079) Change $\frac{15}{8}$:	Answer 1078 $\frac{9}{5} = 1\frac{4}{5}$
1080) $\frac{13}{4} =$	Answer 1079 $\frac{15}{8} = 1\frac{7}{8}$
1081) $\frac{25}{5} =$	Answer 1080 $3\frac{1}{4}$
1082) Which can be changed to a mixed number? $\frac{35}{7}$ $\frac{24}{7}$	Answer 1081 $\frac{25}{5} = 5$
1083) Which can be reduced to lowest terms? $\frac{6}{1}$ $\frac{12}{18}$	Answer 1082 $\frac{24}{7} = 3\frac{3}{7}$
1084) $\frac{2}{4} =$	Answer 1083 $(\frac{12}{18}) = \frac{2}{3}$
1085) $\frac{5}{15}$	Answer 1084 $\frac{2 \div 2}{4 \div 2} = \frac{(1)}{(2)}$
1086) $3\frac{3}{9} = 3\frac{1}{3}$ $3\frac{3}{12} = 3\frac{(\ )}{(\ )}$	Answer 1085 $\frac{5 \div 5}{15 \div 5} = \frac{(1)}{(3)}$

1087) $2\frac{6}{8} = 2\frac{(\ )}{(\ )}$	Answer 1086 $3\frac{(1)}{(4)}$
1088) $\frac{14}{8} = (\ )\frac{(\ )}{(\ )} = (\ )\frac{(\ )}{(\ )}$	Answer 1087 $2\frac{(3)}{(4)}$
1089) $\frac{9}{6} = (\_\_\_\_) = (\_\_\_\_)$	Answer 1088 $1\frac{6}{8} = 1\frac{3}{4}$
1090) $\frac{18}{10} =$	Answer 1089 $1\frac{3}{6} = 1\frac{1}{2}$
1091) $\frac{10}{4} =$	Answer 1090 $1\frac{8}{10} = 1\frac{4}{5}$
1092) $\frac{28}{6} =$	Answer 1091 $2\frac{2}{4} = 2\frac{1}{2}$
1093) $\frac{30}{5} =$	Answer 1092 $\frac{28}{6} = 4\frac{4}{6} =$ $4\frac{2}{3}$
1094) $\frac{22}{7} =$	Answer 1093 6
1095) $\frac{5}{5} =$	Answer 1094 $3\frac{1}{7}$

1096) $\frac{18}{8} =$

Answer 1095

1

1097) To change an improper fraction to a mixed number,

multiply / divide the numerator / denominator by the numerator. / denominator.

Answer 1096

$2\,\frac{2}{8} = 2\,\frac{1}{4}$

1098) When you change an improper fraction to a mixed number, always look at the fraction in the mixed number to see whether you can:

reduce ☐
divide ☐ it.
multiply ☐

Answer 1097

divide
numerator
denominator

1099) Stop!

Place a book mark in this book.
Take TEST-23B in the Yellow Book.

Answer 1098

reduce ☑

Posttest *

1.	$\frac{3}{2} =$	$1\,\frac{1}{2}$	$\frac{2}{3}$	$1\,\frac{2}{3}$	$1\,\frac{3}{5}$	Not given
2.	$\frac{7}{4} =$	$1\,\frac{3}{7}$	$1\,\frac{1}{4}$	$1\,\frac{4}{7}$	3	Not given
3.	$\frac{16}{3} =$	$5\,\frac{3}{16}$	$5\,\frac{1}{3}$	$5\,\frac{13}{16}$	$5\,\frac{2}{3}$	Not given
4.	$\frac{19}{10} =$	$1\,\frac{1}{10}$	$1\,\frac{9}{19}$	$1\,\frac{10}{19}$	$1\,\frac{9}{10}$	Not given
5.	$\frac{16}{5} =$	$5\,\frac{3}{16}$	$1\,\frac{3}{5}$	$3\,\frac{1}{5}$	$3\,\frac{5}{16}$	Not given
6.	$\frac{14}{4} =$	$3\,\frac{2}{4}$	$3\,\frac{4}{14}$	$3\,\frac{2}{7}$	$3\,\frac{2}{5}$	Not given

---

* This is TEST-23B referred to in frame 1099, above.

7. $\frac{18}{8}$ = $2\frac{2}{8}$ $2\frac{4}{5}$ $2\frac{1}{4}$ $1\frac{8}{10}$ Not given

When you are done with this test, have your teacher correct it.

Don't do any more in the Yellow Book or the White Book until your teacher tells you to.

Go to TEST-24A*
Go back to Problem #1049 in Book 6.

****** ****** ******

Review Sheet

1. $\frac{5}{2}$ = $2\frac{1}{2}$ $1\frac{4}{2}$ $1\frac{1}{2}$ $1\frac{2}{2}$ N.G.
2. $\frac{10}{14}$ = $1\frac{4}{10}$ $1\frac{4}{14}$ $\frac{5}{7}$ $\frac{2}{7}$ N.G.
3. $\frac{2}{9} + \frac{7}{9}$ = $\frac{9}{9}$ 1 $\frac{9}{18}$ 2 N.G.
4. $\frac{5}{3}$ = $2\frac{2}{3}$ 1 $2\frac{1}{3}$ $1\frac{2}{3}$ N.G.
5. $\frac{5}{4}$ = 1 $1\frac{1}{4}$ $1\frac{4}{4}$ $\frac{1}{3}$ N.G.
6. $\frac{2}{10}$ = 5 $\frac{5}{2}$ $\frac{1}{5}$ 12 N.G.
7. $\frac{20}{8}$ = $\frac{5}{2}$ $2\frac{4}{8}$ 2 $2\frac{1}{2}$ N.G.
8. $\frac{3}{6} + \frac{3}{6}$ = 1 $\frac{6}{6}$ $\frac{9}{6}$ $\frac{2}{3}$ N.G.
9. $\frac{6}{5}$ = 1 $1\frac{1}{5}$ $\frac{5}{5}$ 2 N.G.
10. $\frac{2}{6} + \frac{4}{6}$ = $\frac{6}{6}$ $\frac{6}{12}$ 1 $\frac{2}{3}$ N.G.
11. $\frac{9}{6}$ = $1\frac{3}{6}$ 1 $3\frac{1}{6}$ $1\frac{1}{2}$ N.G.
12. $\frac{9}{15}$ = $\frac{3}{5}$ $\frac{6}{9}$ 1 $1\frac{6}{15}$ N.G.
13. $\frac{14}{8}$ = $1\frac{6}{8}$ $1\frac{3}{4}$ $1\frac{7}{8}$ 1 N.G.

---

* This is the pretest for Unit 24.

14.	$\frac{3}{8} + \frac{5}{8} =$	1	$\frac{8}{8}$	$\frac{8}{16}$	$\frac{4}{4}$	N.G.
15.	$\frac{1}{9} + \frac{2}{9} =$	$\frac{3}{9}$	3	$\frac{1}{3}$	$\frac{1}{2}$	N.G.
16.	$\frac{14}{10} =$	$1\frac{1}{4}$	$1\frac{4}{10}$	$\frac{7}{5}$	$1\frac{2}{5}$	N.G.
17.	$\frac{10}{8} =$	$1\frac{2}{8}$	1	$1\frac{1}{4}$	$\frac{5}{4}$	N.G.
18.	$\frac{6}{14} =$	$\frac{3}{14}$	2	$\frac{3}{7}$	$\frac{3}{7}$	N.G.
19.	$\frac{9}{2} =$	$4\frac{1}{8}$	$4\frac{1}{2}$	4	$4\frac{5}{2}$	N.G.
20.	$\begin{array}{r} 1\frac{3}{7} \\ +\ \frac{2}{7} \\ \hline \end{array}$	$1\frac{5}{7}$	$\frac{12}{7}$	$\frac{4}{7}$	$\frac{6}{7}$	N.G.
21.	$4 = \frac{28}{}$	4	8	7	3	N.G.
22.	$\frac{7}{9} - \frac{6}{9} =$	$1\frac{3}{9}$	$\frac{13}{9}$	2	$\frac{1}{9}$	N.G.
23.	$\frac{15}{6} =$	$2\frac{1}{9}$	$2\frac{3}{6}$	2	21	N.G.
24.	$\frac{4}{10} + \frac{6}{10} = \frac{10}{10}$		1	$\frac{5}{5}$	$\frac{10}{20}$	N.G.
25.	$\frac{15}{7} =$	$2\frac{8}{7}$	2	$2\frac{1}{7}$	$1\frac{1}{7}$	N.G.

APPENDIX K

Sample Punctuation Unit
Unit 5

Pretest

If there is no apostrophe error, mark Right. If there is an apostrophe error, mark Wrong.

	Right	Wrong
1. her dresses' collars	○	○

(The remaining items follow the form of item 1.)

2. a cars' wheels
3. Jans' arithmetic
4. a captain's ship
5. all the cars' wheels
6. the people's clothing
7. in our tree
8. our doors' are open

---

1. Jimmy's jacket

Which word names the owner?

Jimmy's ≡* jacket ≡*

---

* Indicates response space which was chemically treated in the program.

2. To find out if a word shows ownership, ask yourself two questions:

First, are you told what is owned?

Second, are you told who owns it?

If the answer to both questions is "Yes," the word shows ownership.

Steve's coat

Does the underlined word show ownership?

Yes ≡ No ≡

---

3. boys in the lake

Are you told what is owned? Yes ≡ No ≡

Are you told who owns it? Yes ≡ No ≡

Does the underlined word show ownership? Yes ≡ No ≡

(The remaining items follow the form of items 1-3.)

---

4. drivers keys

or the owner. It still shows ownership.

teachers class

Does the underlined word show ownership? Yes No

---

7. Bills friends

Does the underlined word show ownership? Yes No

---

8. Rule 7: Use an apostrophe to show ownership.

Which shows ownership? Bill went home. Bill's house

9. Show which shows ownership:

the boys bike the boys ran

10. uncles boat

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

11. away from the screams

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

12. the shoes below

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

15. many sisters and brothers

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

16. the policemans whistle

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

17. Mr. Lakes voice

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

---

18. giants were bold

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

---

19. ducks lake

Are you told what is owned? Yes No

Are you told who owns it? Yes No

Does the underlined word show ownership? Yes No

---

20. is rich

Are you told what is owned? Yes No

mans hat and coat
news of the world
whoever comes in
Williams bike
Berts illness
walks around the park
roses smell very sweet
the dogs nose
his sisters car
the players last chance

22. Singular means one. Plural means more than one.

Which is singular? child children

Which is plural? foot feet

---

23. To decide whether a word is singular, ask yourself, "Would I say is or are?"

If the answer would be is - the word is singular.
is = singular

If the answer would be are - the word is plural.
are = plural

birds is
are

birds singular
plural

---

24. Mark each word to show if it would be is or are and to show if it is singular or plural. Be sure to make two marks in each line.

	is	are	singular	plural
Sally				
store				
days				
policeman				
hook				
toss				
surprise				

---

26. Show if each word is singular or plural.

jacket
bus
hiss
guesses
dollars
frost

oxen
paper
hill
rooms
dish
glass

hikes
lakes
churches
mail
fruit
mass

fire
mess
visits
loss
salesmen
yes

27.

	singular	plural		singular	plural
row			tears		
moss			wagons		
prices			trash		
boss			trouble		
firemen			news		
miss			bugs		
steps			map		
pass			saleswomen		

---

28. the players helmet

Does players show ownership? Yes No
Is players singular or plural? singular plural

Players shows singular ownership
plural ownership
no ownership

---

29. the teachers desks

Does teachers show ownership? Yes No
Is teachers singular or plural? singular plural

singular ownership

the firemans badge
the childrens picture
the dress in the store
the feathers were flying
Jim Browns mother
the dogs collar
the monkeys tails
the books have been

my schools team
Johns trip
the salesmens orders
the airplanes wing
the surprise was
the best day
the cars fender
the ants whisker

32.

	Singular Ownership	Plural Ownership	No Ownership
Bills pole			
the puppies food			
the horses ear			
Mothers will come			
the name of a pet			
my brothers shoes			
the flowers grew			

---

33. Rule 7: Use an apostrophe to show ownership.

First decide if the word shows ownership. If it shows ownership, it needs an apostrophe. If it does not show ownership, it does not need an apostrophe.

my friends toy

Does the underlined word need an apostrophe? Yes No

---

34. my eyes opened

Does the underlined word need an apostrophe? Yes No

---

35. Show if the underlined word needs an apostrophe:

	Apostrophe	No Apostrophe
the winners and losers		
the girls hair		
the happiness of the farmers		
Uncle Bills success		
Californias sun		

36.

	Apostrophe	No Apostrophe
the fishs fin		
the birds floated		
the roads were straight		
the Indians corn		

---

37. Sometimes the only way you can tell if a word is singular or plural is by the other words.

Jim owns a book. The boys book is red.

Is the underlined word singular or plural?

---

38. girls book

Does this tell you whether the underlined word is singular or plural? Yes No

39. **girls** book

Does this tell you whether the underlined word is singular or plural? Yes No

---

40. **friends** toy

Does this tell you whether the underlined word is singular or plural? Yes No

---

41. **monkeys** game

Does this tell you whether the underlined word is singular or plural? Yes No

---

42. boy's book

boys' book

To show that an ownership word is singular, use 's. To show that an ownership word is plural, use s'.

	Singular	Plural		Singular	Plural
car's			workers'		
coaches'			duck's		
Sally's			Tim's		
dog's			hats'		
uncles'			roads'		

---

43. A few plural words do not end in s. Use 's for these, just as for singular words.

Show which punctuation is correct:

	Correct	Not Correct		Correct	Not Correct
men's			workmen's		
womens'			mice's		
salesmens'			oxens'		
children's			fishermen's		
firemens'			girl's		

---

44. the **team's** picture

You can tell whether team's is singular or plural if you look at the 's.

team's is singular.

team's is plural.

---

45. the **boys'** uniforms

boys' is singular.

boys' is plural.

46. Tell whether each underlined word is singular or not.

Jack's coat
a beaver's lodge
a child's toys
the teachers' books
the women's hats

---

47. Tell whether each underlined word is plural or not.

Ruth's puppy
the children's bicylces
the birds' feathers
the cat's claws
the parrots' cages
the fathers' meetings

---

48. Some words look like they show ownership, but they do not:

the boy runs

does
runs show ownership.
does not

---

49. Tell whether each word shows singular ownership, plural ownership, or no ownership:

my uncle's boat
my brothers came
my sisters' shoes
my cousins went
my aunts' presents
my grandmother's garden
my father's car
my classmates' papers
my teachers ran
my friends' house
my dogs run
my cow's milk
my pets were
my coat's buttons
my parent's car

---

50. my, your, his, her, our, their
its, yours, hers, theirs, ours

These words show ownership but they are never written with an apostrophe. Show which punctuation is correct:

The book is hers.
their room
The ball was theirs.
our teacher
her' book
The cat drank its own.
his' mother
that one is yours.
Matt lost hi's glove
your' father
my bicycle
The two brother's car struck our bike.
the coaches' picture
the three duck's nests
near the sidelines
the three womens' parties
The two brothers lost their caps, but we didn't lose ours.
The captains of the teams
The yellow one is our's.
The money wasn't their's.

51.	singular ownership	plural ownership	no ownership	not correct
the dog's bones				
the giant's castle				
the players' quit				
the ducks lake				
the children's fair				
Dick's rabbit				
south on Texas street				
Mr. Lake's address				
the boys' address				
the policeman's visit				
the girls' room				
the dogs' kennels				
the kitten's milk				
the cars' wheels				
the players' glove				
the mothers' babies				
the giant's roared				
the fairies' castle				
two dollars' worth				
the bu's stop				
the roses's leaves				
the book's pages				
the houses owners				

******   ******   ******

Posttest

If there is no apostrophe error, mark Right. If there is an apostrophe error, mark Wrong.

	Right	Wrong
1. these ovens are hot		

(The remaining items follow the form of item 1.)

2. the oxen's food
3. some hat's colors
4. and his' ball
5. Buddys football
6. two balloon's strings
7. the cakes are hers'
8. around his neck
9. the field's grass
10. a summers' day
11. signs blinked
12. the giants hair
13. the flowers grew
14. all their sons children
15. give your love
16. this board's color
17. Beth's grandmother
18. three windows broke
19. the styles will change
20. the mens clothes
21. a watch's spring
22. in her' plans
23. these stories' writers
24. the light's will be
25. the summers' were
26. one bridges railing
27. those store's windows
28. the women's hats
29. the dresses on
30. the post's top
31. the arm's are
32. the three glasses' color
33. their best pies
34. the game's end
35. lucky Ann's prize
36. on their farm
37. the dogs collar

38. my uncles' shirt
39. the book of mine
40. the truck's window
41. the puppies sat
42. the coach's uniform
43. on her finger
44. my fathers boat
45. the cap's and covers
46. those letters' heights
47. her mouth's size
48. Lucy' goes there
49. several trees leaves
50. one mens store
51. the sisters desk
52. this players number
53. her red dress
54. our room's number
55. one lock's opening
56. his plow's broke
57. the rooms have
58. the land's size
59. these feathers' colors
60. Debbie's pencil
61. the fishermens' nets
62. the children's party
63. that cows pasture
64. the mices cheese
65. those railroads' land
66. books of theirs'
67. the duck's feet
68. Connie's dress
69. those birds' songs
70. two apron's strings
71. his' blue eyes
72. their good news
73. next Saturday's game
74. Jeffs' father
75. the salesmen's cars
76. the names must
77. my suit's will
78. his suit's color
79. these animals' homes
80. the snow's color
81. Nicholas mother
82. has your ring
83. Paula's notebook
84. those teachers' pupils
85. three babie's bottles
86. Sams' book
87. the telephones have
88. the brothers food
89. some roads' never
90. the detectives' badge
91. Mikes' shoes
92. the workmens' tools
93. our very own
94. four jar's covers
95. the plows dug
96. in your' eyes
97. and my book
98. the trains moved
99. those school's teachers
100. our station's lights

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Achievement Test*

R W R W
1. She was born__April first,_

(The remaining items follow the form of item 1.)

2. Did we move in,_August__1958,_to our new home._
3. Wow._ We're going__Saturday__April,_21,_this year._
4. Was Doris born__Thursday__March,_24,_1959__in Phoenix?_
5. On__April,_2,_1935,_we drove to,_Mayer__Prescott,_and,_Jerome.
6. The class party__the ball game__and__the church picnic,_will be held on__Sunday__April__19,_if it doesn't rain?_
7. Dad asked whether we wanted to go fishing,_or__take a hike next__Saturday?_

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* This is the Review Exercise for Unit 5. Response choices were chemically treated in the program to provide S with immediate knowledge of results.

8. Winter begins the last,_Thursday__in,_December__this year.
9. Stop._ You can't drive__on this street__on Saturdays,_ and Sundays?_
10. The people of__Mexico,_are friendly,_and helpful.
11. This__small,_village__has only one__street.
12. Last week I visited Denver__Colorado,_on Thursday__and,_Friday.
13. The last time I saw__Paris__France,_was in,_September__1962.
14. We drove down four__streets,_in Mesa,_Arizona,_before we found,_Pepper__street.
15. Once we visited our uncle,_in,_Mississippi. His address was__ 131 Stonewall__Avenue,_Jackson,_Mississippi__at that time.
16. The office at__184 Main Street__Peoria,_Illinois__burned to the ground in__January,_1949__didn't it?_

If there is no apostrophe error, mark R. If there is an apostrophe error, mark W.

R W

1. Nancys' bicycle
2. four letter's are
3. the dress' is warm
4. those flie's eggs
5. the hammer is his
6. poor Kay's mother
7. those tents' ropes
8. a car like your's
9. a town's buildings
10. trouble's will end

R W

11. in our' tree
12. that crocodile's mouth
13. several sailors' hats
14. the zoos caretaker
15. the desks and chairs
16. the towns grew
17. the matches' flames
18. a boys' bicycle
19. his name's spelling
20. the visitor's were

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APPENDIX L

Punctuation Achievement Test
Form D (464)

I. Show which mark should end each sentence. Make an X in the right circle.

. ? !

1. Mike doesn't know when you lost it__ ○ ○ ○

(The remaining items follow the form of item 1.)

2. Will Brian be the new captain__
3. The children asked Alan where he had found the board__
4. That is the same story you told me, isn't it__
5. Yippee, let's have another one__
6. Just look at that smoke__
7. In what room is the library__
8. Doesn't David live here__
9. What a stupid thing to do__
10. Wow, that truck is skidding__
11. I have often thought I would enjoy being a cowboy__
12. What is your favorite book__
13. What a mean old man__
14. When Debbie comes, we'll start__
15. The kite flew high in the sky__

II. If the punctuation at the place underlined is right, draw a circle around R. If the punctuation is wrong, draw a circle around W.

R W R W R W R W R W
1. Gray__blue__green,_and,_brown__are nice colors.

(The remaining items follow the form of item 1.)

2. On,_Wednesday,_February__18 it rained.
3. The wind blew hard__the rain,_started to fall__and,_the boy ran home__to his mother.
4. Fred hit the ball__ran to first base__and,_fell down.
5. The hospital is at 24__W. Lock,_Lane__Seattle,_Washington.
6. I spent the summer in Perry__Point__Maryland.
7. Please give the bat to__Bill,_and__me.

8. We met at 1105__Cedar,_this morning.
9. The state of,_Maine,_is far north.
10. The best player__in the school__is my big brother.
11. Both,_1963,_and__1964,_were good__years,_for the farmers.
12. Toronto,_Canada__is a large city.
13. We looked here,_there,_and,_everywhere.
14. The first,_Tuesday__of the__month__was hot.
15. I believe that,_July__1963,_was the hottest month.
16. The address is 219__Ivy__Street__Kingston,_Rhode__Island.
17. In_1965,_my brother will be 14 years old.
18. We visited__Bolivia__and,_Peru,_when we went to__South__America.
19. Do you want to go,_to the zoo__the park,_or the movies?
20. Next,_Wednesday,_we have a school holiday.
21. We left the first__town__at noon.
22. The visit to__Mexico,_was good for Don.
23. Winter begins on the last,_Thursday__in December,_this year.
24. The boys__pulled,_jerked__and,_yanked__at the rope.
25. The 3,_months__of vacation,_passed fast.
26. On October 22,_1952__John was born.
27. This is the fifth__road,_we have crossed.
28. The war began in__Barcelona__Spain.
29. On Saturday,_April 13,_1918,_the ship sailed.

III. If the punctuation is right, mark R. If it is wrong, mark W.

	R	W
1. (book) New Tales	○	○

(The remaining items follow the form of item 1.)

2. two tables legs
3. (song) My Wild Irish Rose
4. am really
5. they've had
6. (book) my school book
7. cos't more
8. of Va.
9. Mabels' necklace
10. di've now
11. couldn't ever
12. (magazine) Saturday Evening Post
13. Fri night
14. his limb
15. ours will be
16. we cant

17. Freddy carrie's
18. the kiss
19. the Sr boys
20. the office's party
21. seven min.
22. (magazine) a good old magazine
23. my own
24. new bldg.
25. four letters' are
26. (newspaper) "Spokane Evening American"
27. (song) "Up the Lazy River"
28. red ink writes
29. Wyo has
30. this monkeys tail
31. (article) a well written article
32. the childrens' books
33. haven't come
34. (poem) "The Worker"
35. (book) the Story of Thomas Edison
36. the saleswomen's uniforms
37. or. not
38. (poem) Forever and Ever
39. grass i's green
40. I'm happy
41. (song) a "beautiful tune"
42. Apr. winds
43. (magazine) Holiday
44. book of mine'
45. wk's after
46. could we
47. my sister's coat
48. a's red
49. (poem) The Long Road
50. weave it
51. S. W. from here
52. sa'id that
53. her' red shoes
54. don't you
55. shed be
56. mo. of
57. (book) "In Our House"
58. the citys schools
59. five doz.
60. the towns grew

END

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